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SHUTTLE USER ANALYSIS (STUDY 2.2)
FINAL REPORT

Volume IV

Standardized Subsystem Modules Analysis

Prepared by

Advanced Mission Analysis Directorate
Advanced Orbital Systems Division

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Volume IV. Standardized Subsystem Modules Analysis

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FOREWORD

The Shuttle User Analysis (Study 2.2) Final Report is comprised of four volumes, which are titled as follows:

Volume I	-	Executive Summary
Volume II	-	User Charge Analysis
Volume III	-	Business Risk and Value of Operations In Space (BRAVO)
		Part 1 - Summary
		Part 2 - User's Manual
		Part 3 - Workbook
		Part 4 - Computer Programs and Data Look-Up
Volume IV	-	Standardized Subsystem Modules Analysis

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1. INTRODUCTION

The purpose of this study was to provide NASA/MSFC with the capability to analyze payloads constructed of standardized modules in analyses of future mission models. The method provides weight and cost factors to be applied in a fashion similar to the low-cost factors presently in use.

NASA/MSFC is currently utilizing in their capture/cost analyses a satellite synthesizing methodology, developed by Aerospace, which has the capability of defining three types of spacecraft: current design modified for reuse, low-cost expendable, and low-cost reusable. The method utilizes the baseline (current design expendable) satellite description and uses growth formulas and subsystem growth factors in a computer program to define the above three types of satellites.

The plan for the study was to use an inventory of standardized module designs obtained from Study 2.1[(1)]. The characteristics of these modules were reviewed for the purpose of reducing the number of different modules and increasing the number of applications of each module to obtain cost reduction. In order to determine the applicability of the modules to new satellites, the driving performance capability(s) (key) of each module was identified. Documentation describing four reference satellites was reviewed to obtain satellite descriptions, program characteristics, and subsystem design parameters used with the key capabilities of the modules to synthesize a standardized configuration. The four reference satellites were the Synchronous Equatorial Orbiter (SEO), the Orbiting Astronomical Observatory (OAO), the Earth Observatory Satellite (EOS), and the Domestic Communications Satellite (COM). The baselines for the reference satellites were the same baselines which were used in the

(1) Study 2.1, "Operations Analysis," examined space servicing of modularized spacecraft. Reference 6 describes the payload design activity associated with this servicing study.

Lockheed Missiles and Space Company's Low Cost Satellite Study[1]. The standardized referenced satellites were then used in conjunction with the baseline satellites to obtain subsystem weight growth factors.

The standardized subsystem module spacecraft descriptions were then used to estimate standardized subsystem and spacecraft costs. Allowances for the sharing of subsystem RDT&E costs between users and a production rate effect applied to unit costs resulting from multiple use are included. These cost estimates were then used with cost estimates of the baseline configuration to develop cost factors. These cost and weight growth factors were put into a form so that they could be applied routinely as a part of the automated capture/cost analysis techniques at MSFC.

The output of this study is an addition to the weight estimating and the payload cost model computer programs to include payloads configured from standardized subsystem modules.

(1) See Reference 1.

2. REFERENCE SATELLITES

The four reference satellites used in this study are the SEO, EOS, OAO, and Comsat, which are the same satellites that were used in the Lockheed low-cost study. The baseline data for the reference satellites are the same as the baseline data used in the LMSC low-cost study.

2.1 PAYLOAD DESCRIPTIONS AND PROGRAM CHARACTERISTICS

Documentation describing the baseline configurations of the reference satellites and the payload descriptions and program characteristics was reviewed. Data describing the satellite dimensions, weight, destination (altitude and inclination), mission, and lifetime parameters are shown in Table 2-1. The following reference documents (see Section 10) were used to obtain the data presented:

1. SEO Reference 1
2. EOS References 2 and 3
3. OAO Reference 1
4. Comsat References 3 and 4.

It should be noted that two of the reference satellites are in synchronous equatorial orbit and the other two are in low earth orbit, one in low inclination and one sun-synchronous.

An additional report describing the Tracking and Data Relay Satellite System (TDRSS) configuration, which was used in Study 2.1 and in this study, is included (Reference 5), since it was assumed that all low earth-orbiting satellites used the TDRSS.

2.2 SUBSYSTEM DESIGN PARAMETERS

These same documents were reviewed to obtain subsystem design parameters for the reference satellites. The general format for presenting the data is the same as used in Study 2.1. These subsystem

Table 2-1. Reference Payload Descriptions and Program Characteristics

Payload Name	Design Parameters			Mission Parameters				Orbital Parameters				Lifetime Parameters			
	Length m (ft)	Diameter m (ft)	Weight kg (lb)	Total No. In System	Required No. In System	Initial Launch Date	Launch Window (Hours)	Altitude km (nmi)	Incl. (deg)	Long. (deg)	V_c mps (fps)	Program Life (Years)	Design Life (Years)	MMD (Years)	Rel. At MMD
1. Sync. Eq. Orbiter (SEO)	2.1 (7)	1.5 (5)	527 (1,163)	4	4	1978 (1966)	Any	35,789 (19,320)	0 0	95W-05W-85E-175E	11,700 (39,600)	7	3	2	0.607
2. Earth Obs. Sat.-C/D (EOS - C/D)	4.9 (16)	2.3 (7.4)	1,781 (3,927)	2	2	1980	3	979.9 (529)	99.36 99.36	9:00 12:00	8,150 (26,740)	10	3	2	0.600
3. Orb. Astro. Obs. - B (OAO-B)	5.2 (17)	2.3 (7.6)	2,182 (4,811)	1	1	1970	Any	740 (400)	35 35		8,135 (26,690)	6	1	1	0.609
4. Domestic Com. Sat (Comsat)	3.3 (11)	3.0 (10)	1,238 (2,729)	3 (1 spare)	2	1975	Any	35,780 (19,320)	0 0	114W-119W	11,700 (39,600)	12	7 (1)	5	0.789

(1) MCI Lockheed design is for 10 years design life. The design is modified to 5 years MMD for this analysis.

design data are used to select modules from the Study 2.1 module inventory to fill design requirements when building a standardized subsystem configuration of the reference satellites. When data were required and not specified, estimates or assumptions based upon mission objectives were made.

Summaries of the attitude and velocity control system (AVCS) subsystem design parameters, which included pointing accuracy, attitude rates, slew angular rates, momentum storage, and attitude and station-keeping thruster data, were extracted from the reference documents or estimated where data were not provided and are presented in Table 2-2.

Similarly, guidance and navigation system (G&N) design parameters are presented in Table 2-3.

The complexity of and the limited information on system requirements for the telemetry, tracking and command (TT&C) subsystem required a number of assumptions to be made. These are listed in Section 5 of Reference 6 (see Section 10) and, therefore, will not be repeated here. The TT&C subsystem requirements interpreted from the reference documents are presented in Table 2-4. Design parameters such as orbit altitude, data bit rate, and data storage are shown in Table 2-5.

As in the other subsystems, the data processing system design parameters were either obtained from the referenced documents or estimated where data were not provided. These data are presented in Table 2-6 and include the number of modules[1] in the standardized design, the data rate and controller program, and data memory requirements.

To design the electrical power system, the average power requirement, payload orbital characteristics, orbit life and solar array data (area, and whether fixed or oriented) are required. Table 2-7 shows these data.

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(1) Modules and space replaceable units (SRUs) used interchangeably.

Table 2-2. Attitude and Velocity Control System Design Parameters

Payload Name	Pointing Accuracy ± (deg)	Attitude Rates, Less Than ± (deg/sec)	Slew Rates ± (deg/sec)	Momentum Storage (ft-lb-sec)	Attitude and Stationkeeping Thrusters		Orientation Reference
					Thrust (lb)	Impulse-Propellant Weight	
1. Sync. Eq. Orbiter (SEO)	±0.1	±0.001	±0.1	12 (RW)	0.1 and 5	60 lb - GN_2	Earth
2. Earth Obs. Sat. - C/D (EOS-C/D)	±0.5	±0.005	±0.1	40 (RW)	0.15 and 5	22 lb - Freon-14	Earth
3. Orb. Astro. Obs. - B (OAO-B)	60→0.1 Arc Sec	1.4×10^{-6}	0.01 - 1.0	3 CMG + 3 RW	0.1 and 5	66 lb - GN_2	Earth
4. Domestic Com. Sat. (Comsat)	±0.14	±0.001	±0.1	30 (RW)	0.5 and 5	405 lb - Hydrazine	Earth

Table 2-3. Guidance and Navigation System Design Parameters

Payload Name	Navigation Accuracy (1σ)		Inertial Measuring Unit	Guidance Computer
	Position m (ft)	Velocity m/sec (ft/sec)		
1. Sync. Eq. Orbiter (SEO)	61 (200)	0.03 (0.10)	No (Tars)	A.C.
2. Earth Obs. Sat. - C/D (EOS - C/D)	27 - 100 (90 - 328)	0.015 (0.05)	S.D. High Performance	A.C.
3. Orb. Astro. Obs. -B (OAO-B)	30.5 (100)	0.015 (0.05)	S.D. + Star Sensor	A.C.
4. Domestic Com. Sat. (Comsat)	61 (200)	0.03 (0.10)	No (Tars)	A.C.

Table 2-4. Telemetry, Tracking and Command Requirements

	Transmitters								Receivers			
	S-40W(1)	S-8W(1)	Non-Standard S-Band	C-0.1W(1)	Non-Standard VHF-Band	K_u-0.1W(1)	Non-Standard K_u-Band	K_u-12W(1)	S-Band	K_u-Band	C-Band	VHF
1. Sync. Eq. Orbiter (SEO)		S-1.5W	S-0.01W						X			
2. Earth Obs. Sat.-C (EOS)	S-25W	S-2.5W						K_u-10.7	X			
3. Orb. Astro. Obs. B (OAO-B)									X			
4. Domestic Com. Sat. (Comsat)				C-0.1W							X	

(1) Denotes Available Standardized Transmitters

Table 2-4. Telemetry, Tracking and Command Requirements (Cont'd)

Payload Name	Com. Signal Cond.	Tracking Circuit	Base-Band Assy.	Antenna: S-Band 1 1/2 Dish	Antenna: K-Band 1 1/2 Dish	Antenna: VHF OMNI	Antenna: S-Band HEMI	Antenna: K-Band HORN	Antenna: C-Band HORN	Recorders: R_1 1 MB/Sec	Recorders: R_2 10 MB/Sec	Diplex	Hybrid	Switch
1. Sync. Eq. Orbiter (SEO)	X		X	X			X			1.6 Mbps / 32 kbps	X	X	X	X
2. Earth Obs. Sat. C/D (EOS-C/D)	X	X			Non-Std. 4 ft		X			1.2 Mbps / 30 kbps	X		X	X
3. Orb. Astro. Obs. B (OAO-B)	X	X		X						X 1042 bps / 66.7 kbps			X	X
4. Domestic Com. Sat. (Comsat)	X								X	None		X	X	X

Table 2-5. Telemetry, Tracking and Command Design Parameters

Payload Name	Orbit (km)	Bit Rate (bps)	Storage (Bits)	TDRS	Number Of Down Links	Antenna Type/Gain	Multiple Servicing (Transponder)	Orientation
1. Sync. Eq. Orbiter (SEO)	Synchronous	1.6×10^6	3.9×10^8	No	2	1 1/2'/ HEMI	1 Link	Earth
2. Earth Obs. Sat. - C/D (EOS - C/D)	980	100 Mbps 1.2 Mbps 400 kbps	6×10^{10}	K_u (SA)	1	(4 ft DRS Dish)	No	Earth
3. Orb. Astro. Obs. - B (OAO-B)	740 (400)	1042 or 66.7K and 1042	Unknown	S (MA)	1	1 1/2'/HEMI	No	Earth
4. Domestic Com. Sat. (Comsat)	Synchronous	1024	None	No	1	HORN/ 11 Db Average	Yes	Earth

Table 2-6. Data Processing System Design Parameters

Payload Name	Number Of SRUs	Data Rate Bus (bps)	No. Channels/ Terminal	No. Commands/ Terminal	Controller Program Memory	Controller Data Memory
1. Sync. Eq. Orbiter (SEO)	12	128K	16	8	2048	4096
2. Earth Obs. Sat. - C/D (EOS - C/D)	17	2048K	16	8	2048	4096
3. Orb. Astro. Obs. - B (OAO-B)	16	256K	32	16	2048	4096
4. Domestic Com. Sat. (Comsat)	13	32K	32	16	2048	4096

Table 2-7. Electrical Power System Design Parameters

Payload Name	Average Power Requirement (Watts)	Maximum Eclipse (Hours)	Eclipses Per Year	Orbital Period (Hours)	Orbit Life/ Design Life (Years/Years)	Selected Depth Of Discharge And Ampere Hours (%)	Installed Energy Storage Requirement (Watt-Hour)	Solar Array Area m^2 (ft^2)
1. Sync. Eq. Orbiter (SEO)	375	1.2	90	24	2/3	60 (26.8 AH)	750	4.9 (52.4) Oriented
2. Earth Obs. Sat. - C/D (EOS - C/D)	750	0.6	5075	1.7	2/3	24 (111 AH)	1875	18.6 (200) Oriented
3. Orb. Astro. Obs. - B (OAO-B)	1200	0.6	5204	1.7	1/2	40 (64 AH)	1800	12.6 (136) Fixed
4. Domestic Com. Sat. (Comsat)	1750	1.2	90	24	5/7	50 (150 AH)	4200	21.4 (230) Oriented

3. SUBSYSTEM DEFINITIONS

The method for synthesizing standardized subsystem satellites makes use of growth factors applied to the baseline subsystem to develop the standardized version. In order to develop these factors, care must be taken to insure that the subsystems are defined in the same way, i.e., components contained in the modularized subsystem version are the same as in the baseline subsystem. The module inventory was reviewed at the component level to determine which modules could be designated as candidates to build subsystems which are compatible with the computer programs in use at MSFC.

The four subsystems and their characteristic components in the weight estimating program for which growth factors were determined are the following:

1. Attitude Control System (ACS) - propulsion
2. Stabilization and Control (S&C) - sensing, computer, reaction wheels, magnetometer, inertial measuring unit
3. Electrical Power System (EPS) - batteries, wiring, solar array
4. Communications, Data Processing and Instrumentation (CDPI) - recorders, transmitters, receivers, antennas.

The following matchup between the modules of Study 2.1 and the computer subsystem definitions is the following:

1. ACS subsystem - AVCS-7* and -8 modules
2. S&C subsystem - All other AVCS plus G&N modules
3. EPS subsystem - EPS modules and solar arrays
4. CDPI subsystem - TT&C and DP modules.

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* See Appendix A for module descriptions.

4. KEYS TO MODULE CAPABILITIES

The program characteristics and subsystem design parameters for the four reference satellites have been presented in Section 2 and the subsystem/module matchup discussed in Section 3. In order to assign modules to satisfy subsystem design parameters and build the reference satellites from standardized subsystem modules, a set of characteristic performance capabilities were developed for the modules. These capabilities, called keys, are in terms of design parameters or defined by a simple calculation using the design parameters.

The keys to the Stabilization and Control (S&C) and the Attitude Control System (ACS) subsystems are presented in Table 4-1. The S&C subsystem keys are pointing accuracy, attitude rates, orbital altitude, and momentum storage. The pointing accuracy and attitude rate, in conjunction with the momentum storage, determine whether a single or three-axis reaction wheel package or control moment gyro is required. The altitude and pointing accuracy determine the sensing module selected. The IMU (Inertial Measuring Unit) and guidance and control computer modules are employed for execution of precise attitude and orbit velocity control requirements. The key to the ACS module selection is the S&C module selection, orbit life, and weight. Thus pointing accuracy, weight, and life determine the quantity (two or four) and the tank size (small or large) module to be selected.

The keys to the electrical power system keys are presented in Table 4-2. The average power required, orbit altitude and subsystem MMD (Mean Mission Duration) are the keys to selection of the electrical power system modules. The orbit period and maximum eclipse time were obtained from the orbital characteristics. The ampere-hour requirement was calculated using the power required, eclipse time, and the depth

Table 4-1. Standardized Module Subsystems Study
Keys to S&C and ACS Module Selection

STABILIZATION AND CONTROL (S&C)

- Pointing Accuracy
  - Low $>0.1^{\circ}$ Earth Horizon Sensor
  - High $\leq 0.1^{\circ}$ Add Star Tracker
- Attitude Rates
  - Low $\leq 10^{-3}$ Deg/Sec
  - High $>10^{-3}$ Deg/Sec
- Orbital Characteristics
  - Altitude > or < 3000 nmi
- Satellite Momentum Storage
  - Up to 10 ft-lb-sec; Up to 30 ft-lb-sec; Up to 500 ft-lb-sec
  - Estimate Momentum Storage Using Weight - ~0.01 x Weight = Momentum Storage

ATTITUDE CONTROL SYSTEM (ACS)

- Key is S&C Module Selection, Life and Weight
- High Pointing Accuracy → Large Tank (4) or Small (4)[(1)] (Medium Momentum Storage)
- Low Pointing Accuracy → Small Tank 2[(1)] or 4 (Low Momentum Storage)
- High Momentum Storage → Large Tank (4)

(1) For short life or small weight.

Table 4-2. Standardized Module Subsystems Study
Keys to EPS Module Selection

ELECTRICAL POWER SYSTEM - EPS
Average Power Required
Orbital Characteristics - Altitude and Inclination
Orbit Period
Maximum Eclipse Time
Subsystem Design Lifetime or Mean Mission Duration (MMD)
Oriented or Fixed Array
Maximum Depth of Discharge - May be Estimated
Calculate Ampere-Hour Requirement (Power Required, Eclipse Time, Depth of Discharge)
Calculate Solar Array Area (Power Required, Time in Sun, Oriented)

of discharge which was estimated. A 28-volt system was assumed in this calculation. If the solar array area was not specified, the area was calculated for oriented or fixed arrays using the data above.

The keys to the CDPI subsystem modules are data storage required, telemetry bit rate, and mission type and are shown in Table 4-3. If the mission type is communications, then the frequency band determines the module selection. For other mission types, and if the altitude is low, the telemetry bit rate selects the module. For high altitude missions (not communications), perigee and apogee altitudes are used to calculate a maximum telemetry bit rate for module selection.

Table 4-3. Standardized Module Subsystems Study
Keys to CDPI Module Selection

COMMUNICATIONS, DATA PROCESSING AND INSTRUMENTATION (CDPI)
Data Storage Required - Recorder Capacity
Always Used with TDRS (Low Altitude Satellites in the Zone of Exclusion), May be Required for Some High Altitude Satellites
Telemetry Bit Rate
Mission
Housekeeping - Assume 1000 bps if not Specified
Mission Type - Communications, Other
If Communications, Frequency Band
If Other High Orbit, Need to Know if Perigee $\geq$ 16,000 nmi and Apogee Altitude
If Other Low Orbit, >2700 nmi $\leq$2700 nmi

5. REFERENCE SATELLITE SYNTHESIS

The buildup of a standardized subsystem module configuration of the four reference satellites was accomplished using the subsystem design parameters of the baseline satellite and the keys to standardized module capabilities. A flow diagram showing the manual procedure for buildup of a standardized subsystem module satellite is shown in Figure 5-1. The first step was to select the module(s) from the Study 2.1 inventory which satisfied the program characteristics and subsystem design requirements. The reference satellite design parameters which were not included in the Study 2.1 module capabilities were satisfied by adding components to the non-replaceable unit, but the weight was charged to the appropriate subsystem for purposes of calculating weight and cost factors. Examples are the tape recorder for the SEO and solar arrays. This non-standard weight was identified for cost estimating. After the subsystems were built up of standardized modules and non-standard components, weights were reallocated for consistency with the baseline subsystem definitions, e.g., the structure was removed from the modules, electrical wiring and power conditioning weights were added to the electrical subsystem, environmental control system weights were removed, etc. This reallocation was also necessary since the subsystem costs were estimated using cost estimating relationships (CERs); thus, structure costs, which are different from electrical subsystem costs, were estimated at the rate for structures and not for the EPS or another subsystem containing structural weight.

5.1 MODULE ASSIGNMENT

The next step in the satellite buildup was the assignment of standardized modules to satisfy the four reference satellite subsystem design parameters. This was accomplished using the keys to the module capabilities. Table 5-1 shows the results of the module assignment by

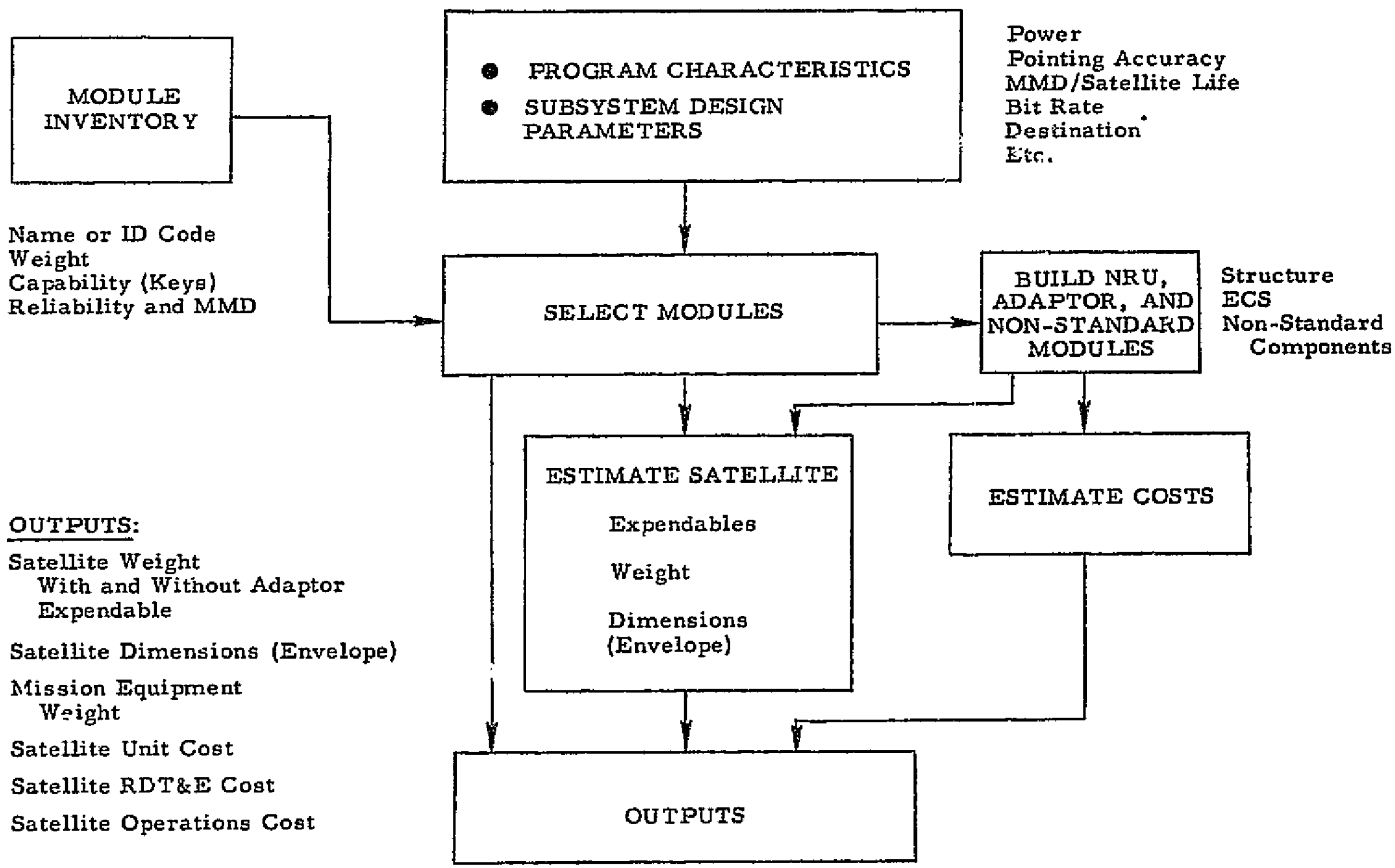

Figure 5-1. Manual Procedure for Satellite Buildup Standardized Module Subsystem Satellites

Table 5-1. Satellite Module Selection

Payload Name	Attitude & Velocity Control			Guidance & Navigation			Telemetry, Tracking & Command			Data Processing			Electrical Power		
	Item	Quant.	Wt. (kg)	Item	Quant.	Wt. (kg)	Item	Quant.	Wt. (kg)	Item	Quant.	Wt. (kg)	Item	Quant.	Wt. (kg)
1. Sync. Eq. Orbiter (SEO)	AVCS-3 AVCS-5 AVCS-7	1 1 4	127.5 55.9 202.4 385.8	GN-2	1	42.6	TT&C-6 Recorder	1 2	54.0 22.0 76.0	DP-1A	1	46.8	EPS-1C EPS-3 Solar Array	1 2 1	105 102 14 221
2. Earth Obs. Sat.-C/D (EOS-C/D)	AVCS-3 AVCS-5A AVCS-8 Dry Propul.	1 1 4 1	127.5 55.9 230.4 413.8 72.6 486.4	GN-1 GN-2	1 1	78.3 42.6 120.9	TT&C-9A TT&C-5A Recorder Non-Std. TT&C Sys	1 1 1 1	67.0 61.0 11.0 21.0 160.0	DP-1B Command Clock	3 1	140.4 9.0 149.4	EPS-1A EPS-2 EPS-3 Solar Array	1 1 2 1	50 131 102 52 335
3. Orb. Astro. Obs.-B (OAO-B)	AVCS-3 AVCS-4 AVCS-6A AVCS-8	1 3 1 4	127.5 398.4 72.5 230.4 828.8	GN-1 GN-2	1 1	78.3 42.6 120.9	TT&C-8 Recorder	2 1	124.0 11.0 135.0	DP-1C	2	93.6	EPS-2 Solar Array	1 1	131 35 166
4. Domestic Com. Sat. (Comsat)	AVCS-2 AVCS-5 AVCS-8	1 1 4	60.9 55.9 230.4 347.2	GN-2	1	42.6 42.6	TT&C-1	1	51.0 51.0	DP-1D	1	46.8	EPS-2 EPS-3 Solar Array	2 2 1	262 102 59 423

subsystem for each satellite and includes the non-standard components discussed in Section 5 above. The standardized modules used in this study are included in Appendix A. The components and weight allocation for each of the modules are listed.

5.2 SUBSYSTEM GROWTH FACTORS (BUILDUP METHOD)

The subsystem growth factors for satellite weight synthesis have been determined by building the subsystems of the four reference satellites from the inventory of modules, adding non-standard components where necessary, reallocating weights into proper subsystems, and then dividing by the baseline subsystem weights. These weights and factors are presented in Table 5-2*. It is noted that the growth factors for the OAO Electrical Power System (EPS) and Communications, Data Processing and Instrumentation (CDPI) subsystems are less than unity and this is due to improved technology over the original design.

The method for applying these growth factors is the same as for the low-cost factors which are presented in Table 5-3* for comparison. The subsystem of a satellite to be synthesized is determined by judgment to be similar to one of the reference satellite subsystems and the growth factor applied to the baseline subsystem weight. Care must be taken in determining the subsystem similarity to obtain a realistic standardized satellite configuration.

5.3 ALTERNATE APPROACH (EQUATION METHOD)

An alternate method does not require the use of a subsystem "similarity" selection. The growth factors determined from the buildup method were plotted as a function of baseline subsystem weight. These are presented for the Attitude Control System (ACS), Electrical Power System (EPS), Stabilization and Control (S&C), and Communications, Data Processing and Instrumentation (CDPI) subsystems in Figures 5-2 and 5-3. The data shows a trend of a high growth factor for small subsystem

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* Table (a) shows weights in metric units; table (b) in English units.

Table 5-2(a). Standardized Subsystem Module Study
Subsystem Weight Factors (Weight in kg)
(Factor Obtained by Buildup)

Item	SEO			EOS			OAO			COM		
	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor
Struct. & Mech.	60	246	4.08	392	545	1.39	517	522	1.01	204	380	1.86
Environ. Cont.	5	24	4.82	50	55	1.09	45	51	1.14	34	38	1.11
ACS	32	70	2.21	105[1]	99/73	1.64	60	98	1.63	91	99	1.09
S&C	62	127	2.06	88	172	1.95	325	488	1.50	57	60	1.06
EPS	141	233/14	1.75	376	373/52	1.13	559	278/35	0.56	328	282/59	1.04
CDPI	67[2]	51/22	1.09	163	123/41	1.01	207	111/11	0.59	27	47	1.75
Mission Equip.	133	133	1.00	541	541	1.00	439	439	1.00	313	313	1.00
Dry Weight	500	920	1.84	1715	2074	1.21	2152	2033	0.94	1054	1278	1.21
Propellant	27	50	1.84	66	80	1.21	30	28	0.94	184	223	1.21
Wet Weight	527	970	1.84	1781	2154	1.21	2182	2061	0.94	1238	1501	1.21

NOTE: Std/Non-Std. Add together for weight factor calculation.

[1] Includes 72.5 kg of dry propulsion.

[2] Included two taperecorders per LMSC A990556, Page 5-74.

Table 5-2(b). Standardized Subsystem Module Study Subsystem Weight Factors (Weight in lb) (Factor Obtained by Buildup)

Item	SEO			EOS			OAO			COM		
	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor
Struct. & Mech.	133	542	4.08	865	1202	1.39	1141	1150	1.01	450	838	1.86
Environ. Cont.	11	53	4.82	110	119	1.09	100	114	1.14	75	83	1.11
ACS	70	155	2.21	230[1]	217/160	1.64	133	217	1.63	200	217	1.09
S&C	136	280	2.06	195	380	1.95	716	1077	1.50	125	133	1.06
EPS	312	516/31	1.75	830	823/115	1.13	1232	612/77	0.56	724	621/130	1.04
CDPI	147[2]	111/49	1.09	360	271/91	1.01	456	245/24	0.59	60	105	1.75
Mission Equip.	294	294	1.00	1192	1192	1.00	967	967	1.00	690	690	1.00
Dry Weight	1103	2030	1.84	3782	4571	1.21	4745	4480	0.94	2324	2819	1.21
Propellant	60	110	1.84	145	175	1.21	66	62	0.94	405	491	1.21
Wet Weight	1163	2141	1.84	3927	4746	1.21	4811	4543	0.94	2729	3310	1.21

NOTE: Std/Non-Std. Add together for weight factor calculation

[1] Includes 160 lb of dry propulsion.

[2] Included two taperecorders per LMSC A990556, Page 5-74.

Table 5-3(a). Subsystem Weight Factors (Low Cost) (Weight in kg)

Item	SEO			EOS			OAO			COM		
	Base	LCR[1]	Factor	Base	LCR	Factor	Base	LCR	Factor	Base	LCR	Factor
Struct. & Mech.	60	570	9.45	392	1007	2.55	517	1212	2.34	204	698	3.42
Environ. Cont.	5	33	6.64	50	68	1.36	45	50	1.10	34	45	1.33
ACS	32	184	5.82	105[2]	89	2.80	60	286	4.75	91	116	1.28
S&C	62	66	1.07	88	96	1.08	325	154	0.47	57	102	1.79
EPS	141	257	1.81	376	902	2.40	559	758	1.36	328	508	1.45
CDPI	67	77	1.16	163	104	0.64	207	141	0.68	27	20	0.75
Mission Equip.	133	195	1.47	541	541	1.00	439	844	1.93	313	342	1.09
Dry Weight	500	1382	2.76	1715	2807	1.64	2152	3445	1.60	1054	1831	1.74
Propellant	27	74	2.74	66	70	1.06	30	145	4.83	184	314	1.72
Wet Weight	527	1456	2.76	1781	2877	1.62	2182	3590	1.65	1238	2145	1.73

[1] Low Cost Reusable

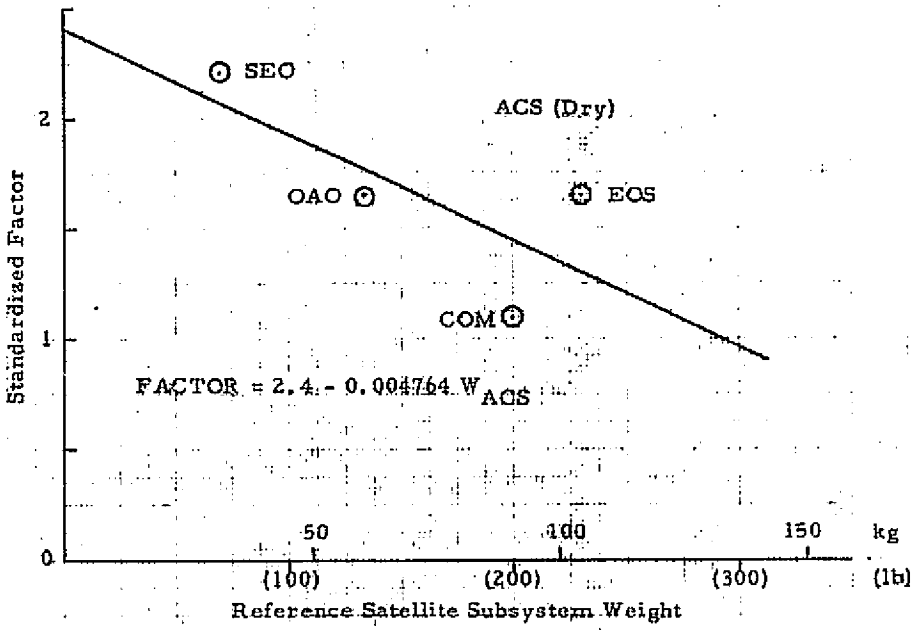
[2] Includes 72.5 kg of dry propulsion.

Table 5-3(b). Subsystem Weight Factors (Low Cost) (Weight in lb)

Item	SEO			EOS			OAO			COM		
	Base	LCR[1]	Factor	Base	LCR	Factor	Base	LCR	Factor	Base	LCR	Factor
Struct. & Mech.	133	1256	9.45	865	2220	2.55	1141	2675	2.34	450	1540	3.42
Environ. Cont.	11	73	6.64	110	150	1.36	100	110	1.10	75	100	1.33
ACS	70	407	5.82	230[2]	196	2.80	133	631	4.75	200	256	1.28
S&C	136	145	1.07	195	211	1.08	716	339	0.47	125	224	1.79
EPS	312	566	1.81	830	1990	2.40	1232	1671	1.36	724	1120	1.45
CDPI	147	169	1.16	360	230	0.64	456	310	0.68	60	45	0.75
Mission Equip.	294	431	1.47	1192	1192	1.00	967	1862	1.93	690	754	1.09
Dry Weight	1103	3047	2.76	3782	6189	1.64	4745	7598	1.60	2324	4039	1.74
Propellant	60	164	2.73	145	154	1.06	66	320	4.85	405	692	1.72
Wet Weight	1163	3211	2.76	3927	6343	1.62	4811	7918	1.65	2729	4731	1.73

[1] Low Cost Reusable

[2] Includes 160 lb of dry propulsion



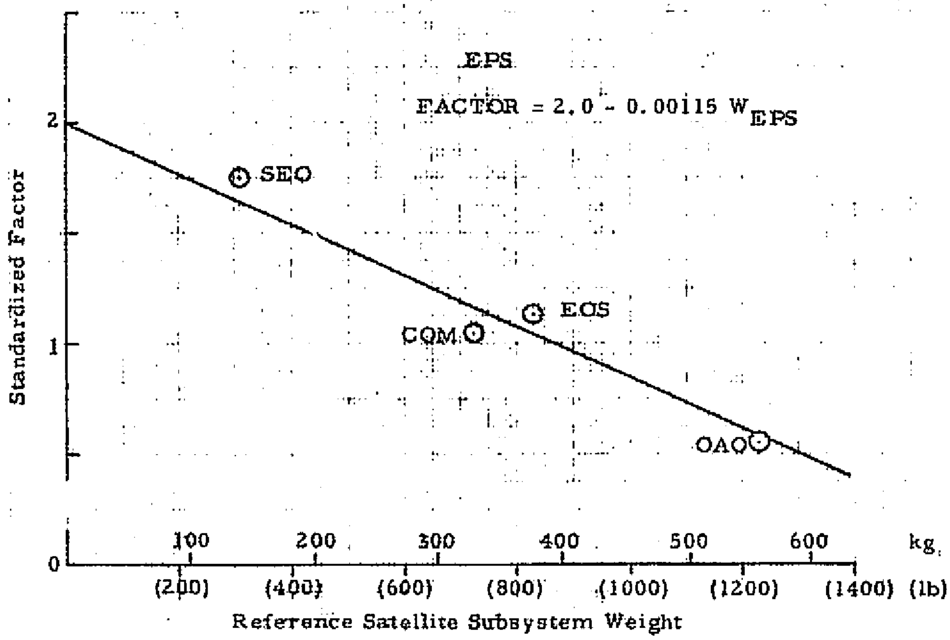
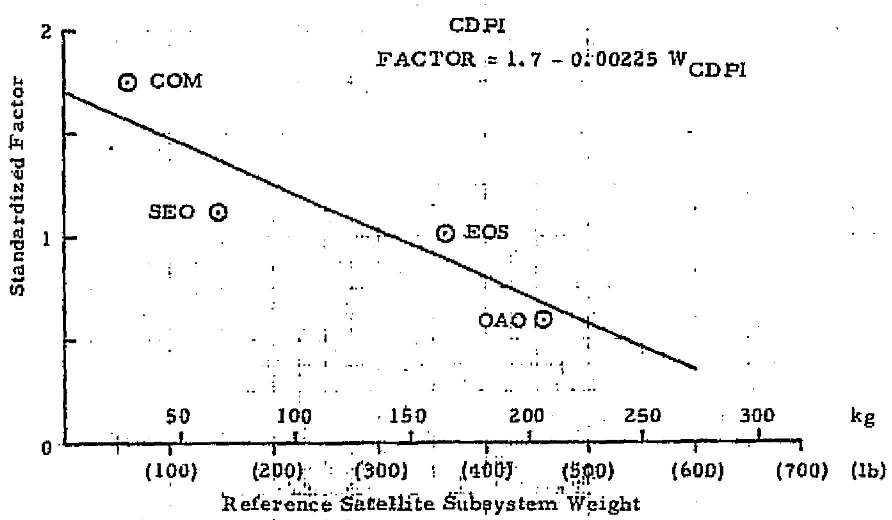


Figure 5-2. Standardized Subsystem Growth Factor As A Function of Reference Satellite Subsystem Weight (ACS, EPS)



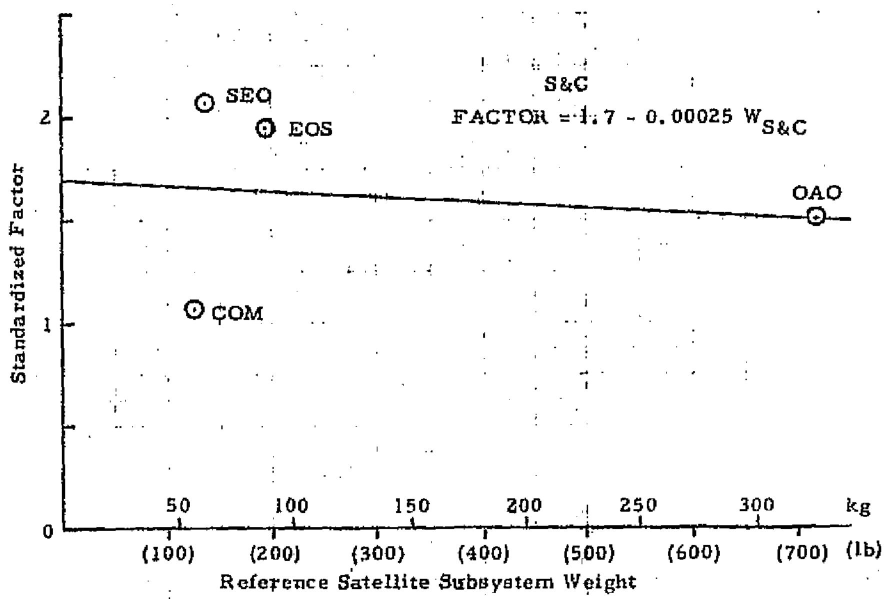


Figure 5-3. Standardized Subsystem Growth Factor As A Function of Reference Satellite Subsystem Weight (CDPI, S&C)

weights decreasing with increased subsystem weights. This is a logical trend since a higher overkill would be expected for small weight subsystems as a result of standardization. A linear fit to the data points was then made and the equation of the line derived. The subsystem growth factor can be determined directly using the baseline subsystem weight without making a subsystem similarity selection. The four reference satellite subsystem weights and growth factors determined by this method are presented in Table 5-4*.

5.4 SATELLITE SIZING (DIMENSIONS)

A method for sizing a satellite which was used in the low-cost satellite study involved the use of a characteristic density curve based upon satellite designs and a pre-selected shape. A more general method was desired for the standardized subsystem module study, i.e., one which does not require a pre-selected shape. The method selected makes use of the number of "average" modules in the synthesized satellite.

A review of the modules of Study 2.1 was made and an average module determined. The average module has a volume of 0.22 m^3 (7.85 ft^3) and weighs 64.5 kg (142.2 lb), including the module structure.

For comparison, a similar review was made of the Lockheed Missiles and Space Company (LMSC) low-cost modules and the average low-cost module was found to be 0.29 m^3 (10.2 ft^3) and weighed 69.4 kg (153 lb). This was as expected since low-cost designs relaxed weight and volume constraints.

The number of modules in a synthesized standardized module satellite was determined by dividing the spacecraft equipment weight plus module structure weight by the average standardized module weight. A configuration based upon a standard module size of 51 x 76 x 71 cm (20 x 30 x 28 in) can be determined which will fit in an envelope

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* Table (a) shows weight in metric units; table (b) in English units.

Table 5-4(a). Standardized Subsystem Module Study
Subsystem Weight Factors (Weight in kg)
(Factor Calculated by Formula)

Item	SEO			EOS			OAO			COM		
	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor
Struct. & Mech.	60	236	3.92	392	503	1.28	517	538	1.04	204	426	2.09
Environ. Cont.	5	23	4.64	50	49	0.99	45	53	1.17	34	42	1.24
ACS	32	66	2.07	105	79/57	1.30	60	106	1.77	91	132	1.45
S&C	62	103	1.67	88	146	1.65	325	494	1.52	57	95	1.67
EPS	141	217/14	1.64	376	346/47	1.05	559	290/36	0.58	328	318/65	1.17
CDPI	67	14/28	1.37	163	109/36	0.89	207	126/13	0.67	27	42	1.56
Mission Equip.	133	133	1.00	541	541	1.00	439	439	1.00	313	313	1.00
Dry Weight	500	884	1.77	1715	1913	1.12	2152	2095	0.97	1054	1433	1.36
Propellant	27	48	1.77	66	74	1.12	30	29	0.97	184	250	1.36
Wet Weight	527	932	1.77	1781	1987	1.12	2182	2124	0.97	1238	1683	1.36

NOTE: Std/Non-Std. Assumes same % as buildup method.

Table 5-4(b). Standardized Subsystem Module Study Subsystem Weight Factors (Weight in lb) (Factor Calculated by Formula)

Item	SEO			EOS			OAO			COM		
	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor	Base	Std. Sub.	Factor
Struct. & Mech.	133	521	3.92	865	1110	1.28	1141	1186	1.04	450	939	2.09
Environ. Cont.	11	51	4.64	110	109	0.99	100	117	1.17	75	93	1.24
ACS	70	145	2.07	230	174/126	1.30	133	235	1.77	200	289	1.45
S&C	136	227	1.67	195	322	1.65	716	1089	1.52	125	209	1.67
EPS	312	481/31	1.64	830	764/104	1.05	1232	640/79	0.58	724	701/144	1.17
CDPI	147	139/62	1.37	360	240/80	0.89	456	279/28	0.67	60	94	1.56
Mission Equip.	294	294	1.00	1192	1192	1.00	967	967	1.00	690	690	1.00
Dry Weight	1103	1950	1.77	3782	4221	1.12	4745	4620	0.97	2324	3159	1.36
Propellant	60	106	1.77	145	162	1.12	66	64	0.97	405	550	1.36
Wet Weight	1163	2056	1.77	3927	4383	1.12	4811	4684	0.97	2729	3709	1.36

NOTE: Std/Non-Std. Assumes same % as buildup method.

4.4 m (14.5 ft) in diameter and 0.9 m (3 ft) long for up to 20 modules. For more than 20 modules a configuration of the type shown in Figure 5-6 should be considered and the envelope length increased by 0.9 m (3 ft) for each layer of modules. The mission equipment length, obtained from the GDC-SSPDA report (Reference 8), is then added to determine the total envelope length. The spacecraft shape can be rectangular (file drawer-type) or circular (donut).

This technique of building spacecraft of standard-sized modules allows the configuration to be compatible with mission equipment and servicing on orbit.

Some conceptual configurations are presented in Figures 5-4, 5-5, and 5-6. Figure 5-4 shows all the modules facing in one direction with the mission equipment mounted on the opposite side. The satellite in Figure 5-5 shows the modules facing from the sides with mission equipment on the top opposite the adapter ring. Some mission equipment could be mounted facing down. Figure 5-6 shows a configuration of layers of modules with mission equipment on the top.

Another possible configuration (not shown) is one where the modules are mounted on a ring structure.

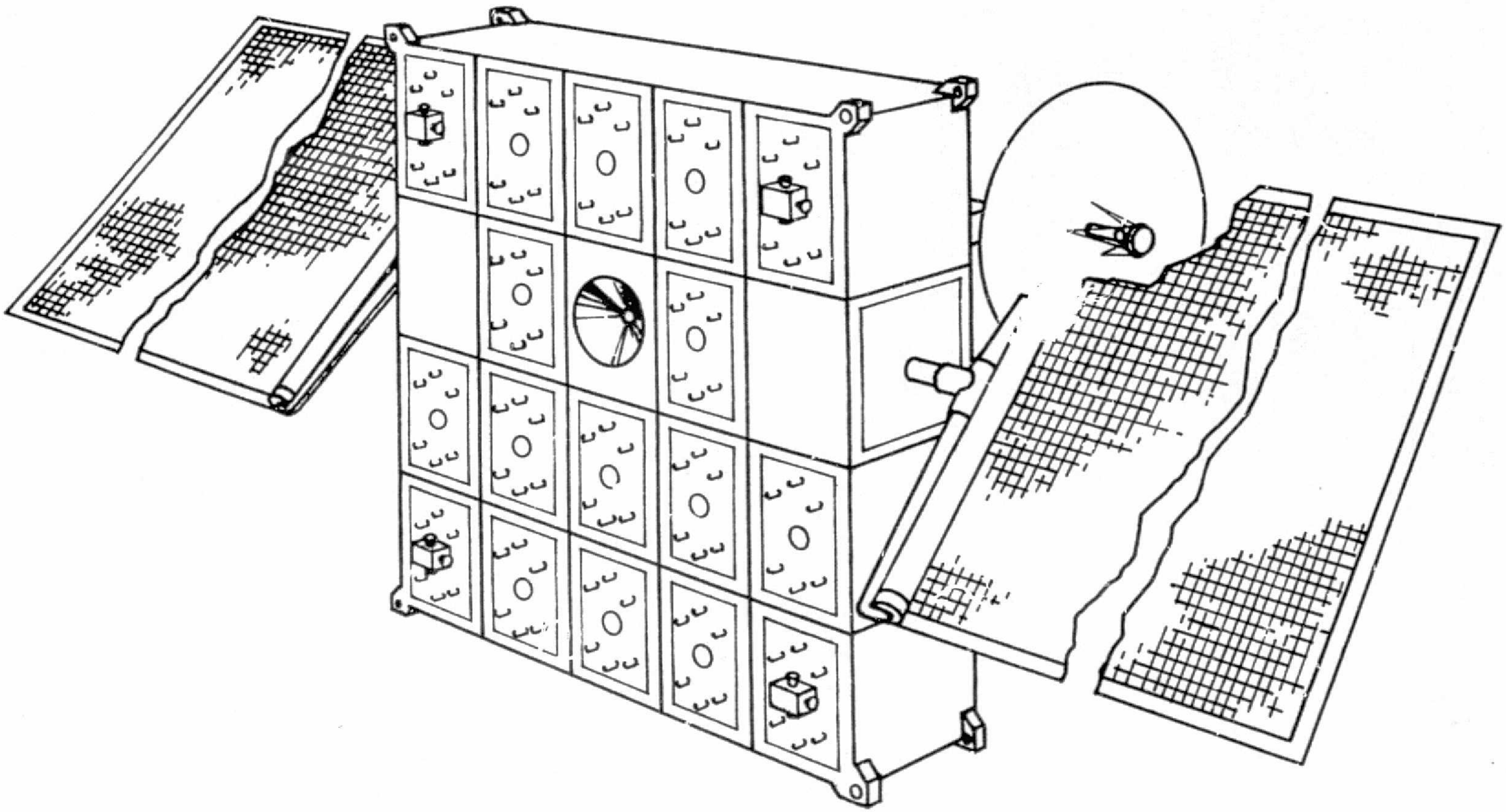

Figure 5-4. Satellite Concept No. 1 Using Standardized Subsystem Modules

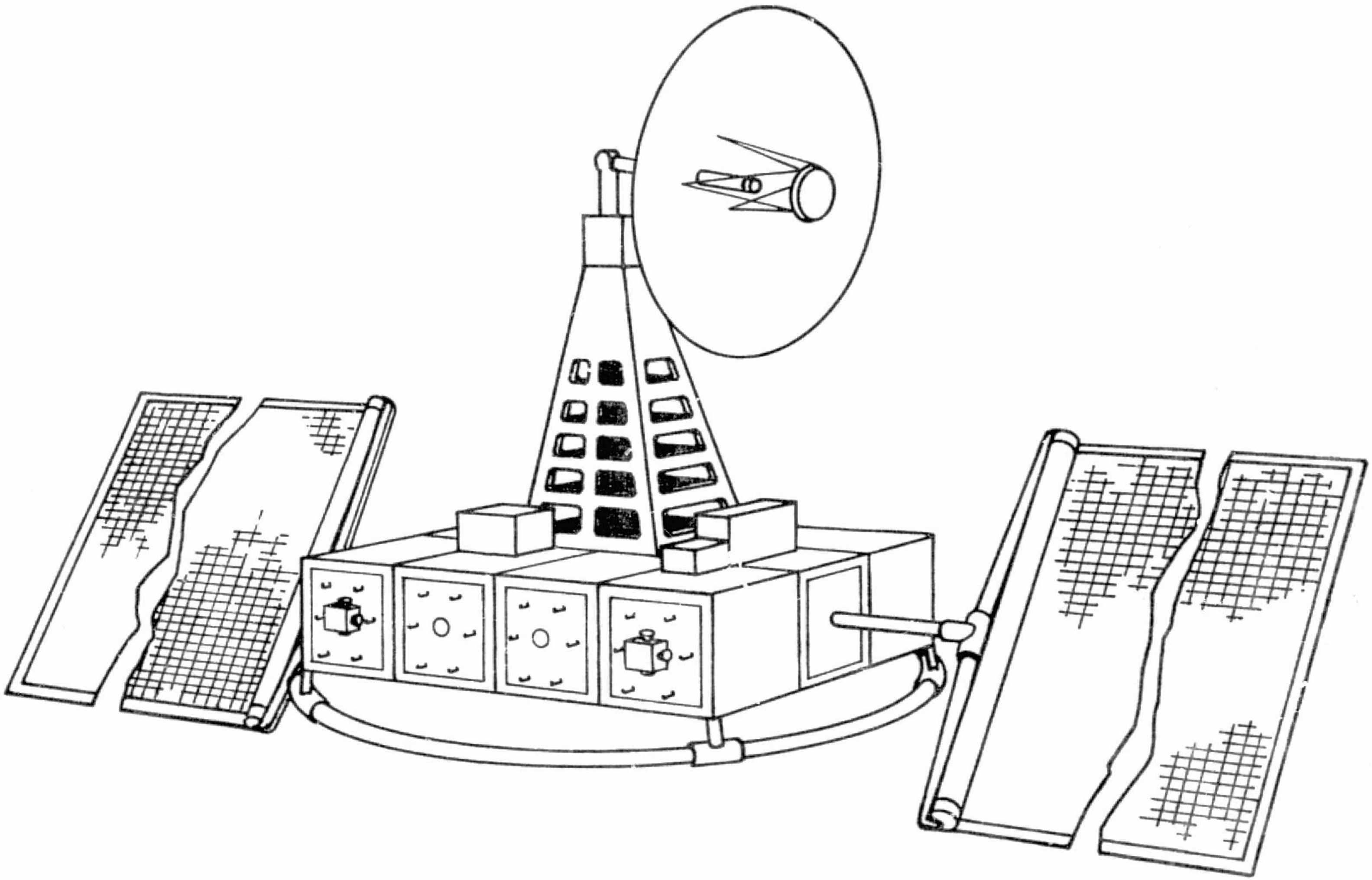

Figure 5-5. Satellite Concept No. 2 Using Standardized Subsystem Modules

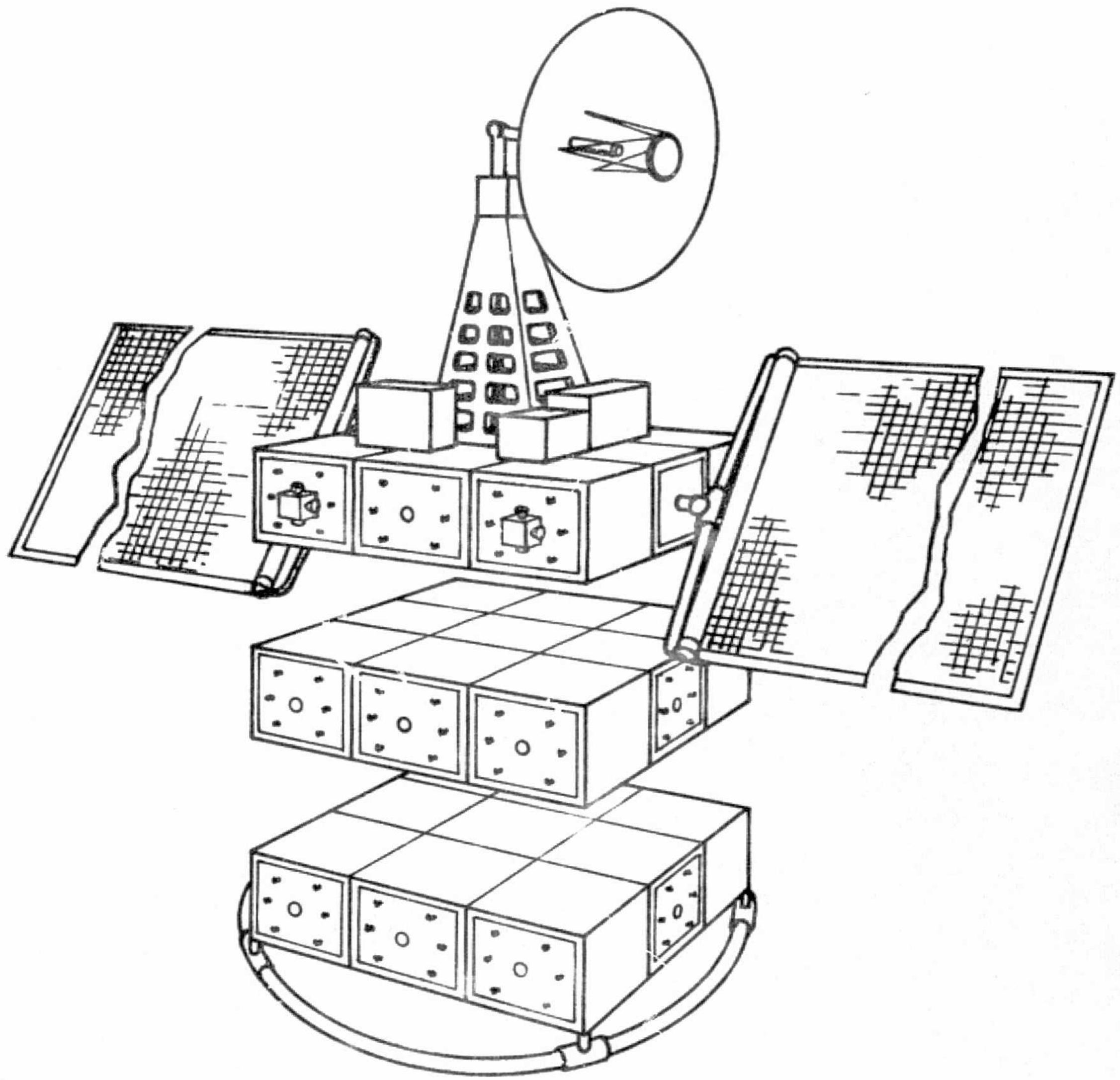

Figure 5-6. Satellite Concept No. 3 Using Standardized Subsystem Modules

6. SATELLITE WEIGHT-ESTIMATING COMPUTER PROGRAM MODIFICATION

NASA/MSFC is currently using a weight-estimating computer program in their capture/cost analyses which was developed by Aerospace. This program makes use of growth formulas and subsystem growth factors to synthesize current design modified for reuse, low-cost expendable, and reusable satellites by applying these factors to subsystem weights of the baseline satellite. Study 2.2 was to add to this computer program the capability of synthesizing a standardized subsystem module satellite using a system similar to the method for low-cost satellites. No changes were made to the program used to estimate weights for the three satellite types mentioned above. The modifications to the program were changes in the printout format and the addition of two factor methods discussed in Sections 5.2 and 5.3 for weight estimating. A sample printout showing the results for the four reference satellites and five example satellites is presented in Appendix B.

The five example satellite programs selected for demonstration of the weight and cost estimating techniques were selected from the DARES printout of the October 1973 mission model and are listed below.

AST-3	Solar Max Sat
PHY-2A	Gravity/Relativity Sat
NEO-6	Tiros
EOP-9	Magnetic Monitor Sat
NND-5	Foreign Comsat

The selection was made on the basis of the various combinations of reference satellite subsystem types selected by similarity and using a variety of program types, i.e., NASA astronomy, physics, earth observations, and non-NASA communications.

The first modification to the printout format is the addition of a column for standardized subsystem factors which are input as a table in the program and used as in the low-cost configurations by subsystem similarity selection. When the alternate method is used for calculating the growth factor by equation, the resulting growth factor is printed in this column. A second modification to the printout format adds a column of standardized subsystem weights, total dry weight, ACS propellant wet weight, adapter weight, and total launched weight. Envelope diameter and length, mission equipment length and diameter (mission equipment dimensions are obtained from the GDC-SSPDA report, Reference 8), and number of modules have been added to the format.

A new algorithm was developed for calculating the structure weight as a function of equipment weight. The formula was obtained from a TRW modular design of the DSCS-II. It was determined that the average module structure weight was 0.157 times the equipment weight in the module. The NRU (space frame) structure was 0.157 times the total equipment and module weight. Therefore, the total structure weight is the sum of the two, or, structure weight = 0.339 (total equipment weight).

The environmental control system weight algorithm was changed to 2-1/2 percent of the total spacecraft weight. This algorithm is used in other synthesis programs. The other configurations make use of a scaling factor based upon satellite external area. However, in order to remain more general in application, no shape is assumed for the standardized satellite, only an envelope. The 2-1/2 percent factor was added, therefore, to the program.

The other addition to the program was to add the equations for the subsystem growth factors which are discussed in Section 5.3.

These additions have been made to the weight-estimating program and the results shown on a copy of the printout in Appendix B.

7. COST ESTIMATING METHOD

For payload cost estimating purposes, MSFC is using a computer program (PALCM) originally developed by The Aerospace Corporation and subsequently modified by MSFC. The program deals with four types of satellite designs: current expendable, current reusable, low-cost expendable, and low-cost reusable. To give greater flexibility to the cost model, a study concerning cost estimating of standardized subsystems has been undertaken. Standardized subsystems can be considered surrogates for standardized module design concepts; accordingly, the cost model's usefulness was extended to on-orbit maintenance modes of operation. The objectives, methods, and results of the study as they refer to cost estimating procedures are presented in this section.

7.1 OBJECTIVE

In essence, the primary goal of the study was to develop ways of estimating the effect on cost of the adoption of standardized modules for use in a current design reusable type of satellite. In the interest of economy, the concept of cost factors has been adopted and is applied in much the same manner as low-cost factors are used when low-cost designs are considered by the cost model. For example, tables of factors can be stored in the program and can be called up in the same way that low-cost subsystem factors are identified and used. Such procedures for implementing standardized subsystem cost estimating result in minimal changes to the PALCM program. The application of factors also allows the use of baseline data previously developed, i.e., no additional basic design inputs are required.

7.2 PROCEDURE FOR DEVELOPING FACTORS

The first step in the development of cost factors was the preparation of cost estimates for baseline (B/L) and standardized (STD) subsystem designs for a series of pertinent satellites. The satellites selected were EOS, SEO, OAO, and Comsat. In the second step, a comparison was made of standardized and baseline RDT&E and unit costs for each selected satellite subsystem to obtain a set of subsystem cost factors. Next, the factors in tabular format (exactly the same as that used for the low-cost factors), together with a procedure for identifying standardized designs, was incorporated in the PALCM program. Finally, the procedure was applied to a sample of five satellites and a comparison was made with other design concepts such as low-cost or current reusable for ground refurbishment. The major steps mentioned above are considered in detail in the following sections.

7.2.1 Baseline Cost Estimates

The PALCM computer model was used in conjunction with the reference satellite weight and performance data, as shown in Table 7-1, to produce baseline cost estimates for the SEO, EOS, OAO, and COM satellites. Table 7-1 contains the results of the PALCM output by RDT&E and first unit cost and by subsystem for each of the reference satellites. Values for the electrical and TT&C subsystems on OAO are excluded because the weights of the standardized modules were substantially below those for the reference satellite and unrealistic factors would therefore have been generated. As an alternative, the average for the other three satellites was used as a factor for these particular OAO subsystems. (Note that the same phenomenon occurred in the original development of low-cost factors from the LMSC study data.)

Table 7-1. Baseline Subsystem Costs for Reference Satellites (Millions of 1972 Dollars)

Subsystem	SEO		EOS		OAO		COMSAT	
	RDT&E	Unit	RDT&E	Unit	RDT&E	Unit	RDT&E	Unit
Structure	14.394	2.958	19.979	4.484	21.034	4.857	17.601	3.744
Electrical	7.870	1.301	10.095	1.744	N/A	N/A	14.041	2.620
TT&C	14.684	4.910	30.504	12.537	N/A	N/A	8.222	1.795
Stability & Control	26.354	4.977	44.179	10.523	64.408	16.818	53.560	13.443

N/A = Not Applicable

7.2.2 Standardized Subsystem RDT&E Cost Factors

The same PALCM program was used to develop RDT&E cost estimates for the STD subsystems, except that in addition, factors were applied to each subsystem to reflect (1) the STD vs peculiar split, (2) the anticipated number of programs sharing the subsystem, and (3) the average percentage of component cost per subsystem versus the total cost of the subsystem (including system-related costs). For example, if on the average 50 percent of RDT&E cost for a particular subsystem is attributable to component cost, if the STD portion of the new subsystem design is 80 percent, and if the subsystem will be shared with ten other programs, then the resulting "savings" would be 36 percent (9/10 of 80 percent of 50 percent) and the factor to apply to the STD subsystem cost estimate would be 64 percent (1 - 0.36). If costs for the STD subsystem, without sharing, were 25 percent more than the baseline subsystem cost, the net effect in the example above would be a STD factor of 0.800 to be applied to the baseline cost estimate.

From past satellite programs, it has been determined that component cost versus total subsystem cost averages out to be as follows:

Structure	52 percent
Electrical	37 percent
TT&C	48 percent
Stability and Control	41 percent

To calculate the sharing of subsystems, the DARES printout for the October 1973 mission model was reviewed to determine the number of NASA and non-NASA programs that identified selected subsystems similar to the subsystem in any of the four reference satellites. The number of programs found to share ACS, S&C, CDPI, and EPS subsystems is tabulated in Table 7-2 for the reference satellites.

Table 7-2. Satellite Programs Sharing Subsystem Modules Based on 1973 Mission Model DARES Printout (NASA/Non-NASA Programs)

Subsystem	Reference Satellite			
	SEO	EOS	OAO	COMSAT
ACS	12	5	13	29
S&C	13	15	8	9
EPS	15	5[1]	18	8
CDPI	25	4	6	5[1]

(1) DOD programs are included.

The standardized portion of each subsystem was found to be as follows:

Subsystem	SEO	EOS	OAO	COM
Electrical	0.952	0.885	N/A	0.840
TT&C	0.693	0.751	N/A	1.000
Stability & Control	1.000	0.789	1.000	1.000

7.2.3 Standardized Subsystem Factors for Unit Cost

The PALCM program was used to generate first unit cost for each standardized subsystem. Factors were applied to the STD unit costs to give effect to quantity production. Data needed to develop such factors included (1) the STD portion of each subsystem mentioned above, (2) the learning curve to be applied to that STD portion, and (3) the quantity of new satellites that conceivably would be using the same particular subsystem. The learning curve selected was a 90 percent log-linear cumulative average function. The quantity of satellites was based on data in the previously mentioned DARES printout, used in conjunction with the payload launch schedule from the October 1973 Space Shuttle traffic model (Ref. 7, Section 10) to obtain a module count of all new satellites launched. Tabulated results are given in Table 7-3 for the four satellite programs.

The results of the calculations described in this and the preceeding section are shown in Table 7-4 and cover RDT&E and unit cost factors to be applied to baseline cost estimates to produce standardized subsystem costs. An estimate for ground support equipment (GSE) is also provided and is based on an average of the RDT&E factors, exclusive of structure, for the subsystems of the reference satellite. Note that factors for structure are higher than the other subsystems, due to the lack of assumed sharing and no common production.

Table 7-3. Satellites Using Standardized Subsystem Modules Based Upon 1973 Mission Model Traffic (NASA/Non-NASA Programs)

Subsystem	Reference Satellite			
	SEO	EOS	OAO	COMSAT
ACS	33	12	24	98
S&C	37	37	15	47
EPS	50	3	39	29
CDPI	54	9	10	36

Table 7-4. Standardized Subsystem Cost Factors

Subsystem	SEO		EOS		OAO		COMSAT	
	RDT&E	Unit	RDT&E	Unit	RDT&E	Unit	RDT&E	Unit
Structure	1.00	1.33	0.83	1.13	0.78	1.01	0.87	1.18
Electrical	0.75	0.87	0.96	0.94	0.84	0.83	0.63	0.68
TT&C	0.55	0.75	0.51	0.79	0.56	0.88	0.61	1.10
Stability & Control	0.76	1.07	0.84	0.88	0.62	0.85	0.51	0.55
System GSE	0.69	N/A	0.77	N/A	0.67	N/A	0.58	N/A

N/A = Not Applicable

7.3 COST MODEL PROGRAM MODIFICATION

As previously discussed, one of the objectives of the study was the implementation of standardized subsystem cost-estimating procedures in the existing PALCM program with a minimum of changes or added complexity. Because the STD factor method considered in this section closely parallels the PALCM treatment of low-cost satellite designs, the program was easily modified. First, a change was made to the satellite input sheet to use "S" rather than "L" (in column 18) as the satellite type identifier. Next, the table of factors, from Table 7-4, was placed in the program in exactly the same format used for the low-cost factor tables. Finally, the output was changed so that "standardized" rather than "low cost" was used for various titles.

7.4 APPLICATION TO SELECTED SATELLITES

Five satellites from the October 1973 mission model were selected for testing and analyzing the application of STD factors. The satellites are listed below with their DARES identification code and the baseline (current expendable) weight.

Satellite	DARES Code	Baseline Weight, kg(lb)	
Solar Max	AST-3	1,437	(3,168)
Gravity Gradient	PHY-2A	481	(1,060)
Tiros	EO-6	641	(1,414)
Magnetic Monitor	EOP-9	172	(380)
Foreign Comsat	NND-5	336	(741)

The outcome of applying the STD factors within the PALCM program is shown in Table 7-5. It can be seen that the standardized results are lower in RDT&E cost than those for expendable designs in all cases, lower than CDR in most cases, and usually higher than LCR. A similar picture emerges for unit cost; however, the percentage decreases in cost are not as great as those for RDT&E, and in several instances unit costs are higher than the baseline.

Table 7-5. Comparisons of Cost for Selected Satellites

	SOLAR MAX SATELLITE				GRAVITY - GRADIENT				TIROS				MAGNETIC MONITOR				FOREIGN COMSAT			
	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD
<u>RDT&E</u>																				
Structure	19	16	11	15	7	8	4	5	9	9	5	7	12	12	7	12	7	8	4	7
Electrical	7	6	5	6	5	4	3	4	7	6	4	6	6	5	4	5	6	6	5	5
TT&C	14	9	8	14	--	--	--	--	7	6	7	7	6	5	4	3	5	5	5	5
Stab. & Contr.	47	35	32	39	32	25	25	20	21	18	15	18	16	15	11	14	24	20	15	18
	(87)	(66)	(56)	(74)	(44)	(37)	(32)	(29)	(44)	(39)	(31)	(38)	(40)	(37)	(26)	(34)	(42)	(39)	(29)	(35)
<u>UNIT</u>																				
Structure	4.3	4.8	3.1	4.4	0.7	1.3	0.5	0.8	1.2	1.7	0.8	1.2	2.6	3.0	1.4	3.4	.9	1.4	0.5	1.2
Electrical	1.1	1.3	0.9	0.9	0.8	0.9	0.6	0.7	1.1	1.1	0.8	0.9	1.0	1.0	0.8	0.9	1.0	1.1	0.8	0.9
TT&C	4.6	4.6	3.6	4.6	---	---	---	---	1.4	1.4	1.4	1.4	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.6
Stab. & Contr.	11.4	11.5	9.4	10.1	6.9	6.9	5.9	5.9	3.6	3.6	3.0	3.2	2.1	2.1	1.7	1.8	4.5	4.5	3.6	4.8
	(21.4)	(22.2)	(17.0)	(20.0)	(8.4)	(9.1)	(7.0)	(7.4)	(7.3)	(7.8)	(6.0)	(6.7)	(6.6)	(7.0)	(4.7)	(6.8)	(7.0)	(7.6)	(5.5)	(7.5)

[1] Baseline

8. ALTERNATIVE COST-ESTIMATING METHOD

From the discussion in Section 5, it appeared that the initial method used to estimate weight changes for standardized subsystems contained certain deficiencies. The method developed to counter the drawbacks observed relies entirely on subsystem rather than satellite types for applying adjustment factors. For cost-estimating purposes, a similar reorientation is needed, i.e., reference satellite types (SEO, EOS, OAO, and Comsat) are no longer used to identify cost factors. Moreover, cost factors make up only one of several steps in the estimation of cost. Many of the details needed to develop the alternate method, however, can be taken directly from the initial work.

8.1 PROCEDURE

The first step is to identify the average standardized (STD) versus non-STD split for each subsystem. Next, the average sharing of programs by subsystem is estimated -- to be used for RDT&E sharing calculations. Similarly, the total average quantity to be bought for each subsystem is derived -- to be used in learning curve adjustments for unit production. Finally, the component versus system oriented cost is needed, and the same figures used for the initial method apply. All of these data are contained in Table 8-1. In addition, the table contains factors that are derived from the data.

At this juncture in the discussion, it should be noted that the PALCM program has not been modified to automatically produce cost estimates required by the alternate method. For the current study, all estimates produced by the PALCM program rely on manual (namelist) inputs. Accordingly, to eliminate extensive manual inputs, the following steps must be taken to provide PALCM with an automatic feature. First, weight and performance data for the STD design version of a satellite is

Table 8-1. Data for Alternative Method

Subsystem	STD/STD + Non-STD	Sharing		Component Percentage	Factor	
		RDT&E	Prod.		RDT&E	Unit
Structure	N/A	N/A	N/A	52	1.00	1.00
Electrical	0.885	10	30	37	0.71	0.64
TT&C	0.838	10	27	48	0.64	0.67
Stability & Control	0.950	10	38	41	0.65	0.60
GSE	-----	--	--	--	0.66	---

needed; recall that the previous method requires only baseline design data. Such information must be an input either along the lines of another DARES deck or a routine must be built into the PALCM program similar to that described in Section 5 for the alternative weight-estimating program. Secondly, the factors shown in Table 8-1 must be programmed into PALCM. Next, a means of flagging STD design satellites must be incorporated on the payload input sheet -- the same flag previously mentioned could be used, i.e., an "S" could be input in column 18 or column 24. Finally, PALCM must be modified so that it treats the STD weights as if they were reusable designs and apply the CERs and stored factors directly to the weights. An exception should be made in the case of the electrical subsystem. If the wattage does not increase for the STD design over the baseline design, but the weight does, a means of estimating the higher cost for the STD subsystem must be incorporated in PALCM.

For the current study analysis, the electrical subsystem has been considered to be a CDR design for cost-estimating purposes. In such a method, the STD weight is compared with the baseline weight and an additional cost factor is automatically generated within PALCM.

The outcome of applying the STD factors within the PALCM program is shown in Table 8-2. The values shown represent outputs based on namelist (manual) inputs. RDT&E cost estimates for STD satellites are generally lower than CDE or CDR, but are higher than LCR; unit costs generally show little reduction over CDR satellites and are higher in several instances.

8.2 OBSERVATIONS

The alternate method of estimating the cost of STD subsystems relies on average values for subsystems and differs from the initial method considered in that the type of satellite need not be identified. In general,

Table 8-2. Comparisons of Cost for Selected Satellites

	SOLAR MAX SATELLITE				GRAVITY - GRADIENT				TIROS				MAGNETIC MONITOR				FOREIGN COMSAT			
	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD	CDE[1]	CDR	LCR	STD
RDT&E																				
Structure	19	16	11	15	7	8	4	10	9	9	5	10	12	12	7	12	7	8	4	9
Electrical	7	6	5	5	5	4	3	4	7	6	4	5	6	5	4	5	6	6	5	5
TT&C	14	9	8	7	--	--	--	--	7	6	7	5	6	5	4	4	5	5	5	3
Stab. & Contr.	47	35	32	33	32	25	25	26	21	18	15	15	16	15	11	12	24	20	15	18
	(87)	(66)	(56)	(60)	(44)	(37)	(32)	(40)	(44)	(39)	(31)	(35)	(40)	(37)	(26)	(33)	(42)	(39)	(29)	(35)
UNIT																				
Structure	4.3	4.8	3.1	4.6	0.7	1.3	0.5	2.0	1.2	1.7	0.8	1.9	2.6	3.0	1.4	3.2	0.9	1.4	0.5	1.6
Electrical	1.1	1.3	0.9	1.0	0.9	0.6	0.7	0.8	1.1	1.1	0.8	1.0	1.0	1.0	0.8	1.0	1.0	1.1	0.8	1.0
TT&C	4.6	4.6	3.6	4.3	---	---	---	---	1.4	1.4	1.4	2.2	0.9	0.9	0.8	1.1	0.6	0.6	0.6	0.8
Stab. & Contr.	11.4	11.5	9.4	10.6	6.9	6.9	5.9	8.0	3.6	3.6	3.0	3.6	2.1	2.1	1.7	2.3	4.5	4.5	3.6	4.6
	(21.4)	(22.2)	(17.0)	(20.5)	(8.4)	(9.1)	(7.0)	(10.8)	(7.3)	(7.8)	(6.0)	(8.7)	(6.6)	(7.0)	(4.7)	(7.6)	(7.0)	(7.6)	(5.5)	(6.0)

[1] Baseline

both methods show savings in RDT&E over current design type satellites; however, unit costs exhibit little or no decrease. Such an outcome is expected because savings associated with quantity production tend to be offset by the broader requirements inherent in STD subsystems. The potential for savings is enhanced, however, because the on-orbit servicing mode with STD subsystem modules should produce substantial reductions in the cost of satellite operations.

9. CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to provide NASA/MSFC with the capability to include standardized subsystem module satellite types in their capture/cost analyses of future mission models. The results of this study are additions to the satellite weight-estimating computer program and payload cost-estimating program which provide this capability using a system similar to the method currently in use for low-cost design satellite configurations.

The following conclusions and recommendations result from the study.

1. The two growth factor synthesis methods provide logical configurations for satellite type selection. The standardized subsystem configuration is generally heavier than the "current design modified for reuse" and lighter than the "low cost" configurations which is a result from overkill due to standardization.

2. If the method which depends upon a subsystem similarity selection (i.e., the subsystem is similar to one of the four reference satellites) is used, care must be exercised in the subsystem similarity selection. If the baseline satellite subsystem weight varies greatly from the "similar" reference satellite subsystem weight, the synthesized subsystem will not represent a standardized subsystem when the weight and cost factors are applied. This method is <u>not</u> recommended.

3. The alternate method, which determines the growth factor as a function of the baseline subsystem weight, provides a larger growth factor for small subsystem weights and results in a greater overkill due to standardization. No subsystem type similarity selection is necessary. This is the <u>recommended</u> method.

4. It is recommended that the application of standardized subsystem factors be limited to satellites which have baseline dry weights from about 317 kg (700 lb) to 2,948 kg (6,500 lb). The lower limit is based upon a minimum number of six modules (two ACS, one EPS, one S&C, one CDPI, and one solar array). The upper limit is an estimate based upon the reference satellites studied.

5. It is not recommended that standardized subsystem growth factors be applied to spin-stabilized spacecraft, since the inventory of modules was obtained from Study 2.1, where spinners were not considered by ground rule.

6. The standardized satellite design approach applies to satellites maintainable on orbit or retrieved for ground maintenance.

7. The design concepts are general, not tied to specific packaging or orbital maintenance concepts.

8. Standardized satellite cost reductions over baseline satellite costs are significant.

9. Standardized satellite cost changes relative to current design reusable spacecraft depend upon the satellite studied, and on the average show a modest savings.

10. Standardized satellite costs relative to low-cost reusable satellite costs are slightly higher.

10. REFERENCES

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APPENDIX A

The modules used in this study for the AVCS, G&N, TT&C, DP, and EPS subsystems are listed in this appendix. This listing identifies the components and their weights for each module.

Table A-1. Standardized Subsystem Modules
Attitude and Velocity Control System

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
AVCS-2	Reaction Wheel (10 ft-lb-sec)	A	Reaction Wheel	1	8.2	8.2
		B	Wheel Electronics	1	1.4	1.4
		C	Magnetometer(3 Axis)	1	3.2	3.2
		D	Amplifier	1	1.4	1.4
		E	Coil	3	4.6	13.7
		F	Remote Terminal	1	2.0	2.0
		G	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			60.9
AVCS-3	Reaction Wheel (10 ft-lb-sec/ wheel)	A	Reaction Wheel	3	24.5	73.5
		B	Wheel Electronics	1	2.7	2.7
		C	Magnetometer (3 Axis)	1	3.2	3.2
		D	Amplifier	1	1.4	1.4
		E	Coil	3	4.6	13.7
		F	Remote Terminal	1	2.0	2.0
		G	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			127.5
AVCS-4	Control Moment Gyro (Double Gimbal) (500 ft-lb-sec)	A	CMG Wheel	1	68.0	68.0
		B	Wheel Electronics	1	4.5	4.5
		C	Torquer,Damper & Resolver	2	4.5	4.0
		D	Magnetometer (3 Axis)	1	3.2	3.2
		E	Amplifier	1	1.4	1.4
		F	Coil	3	4.6	13.7
		G	Remote Terminal	1	2.0	2.0
		H	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			132.8

NOTE: AR = As Required

Table A-1. Standardized Subsystem Modules
Attitude and Velocity Control System (Cont'd)

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
AVCS-5	Sensing	A	Aux Electronics Assy (AEA)	1	4.5	4.5
		B	Rate Gyro Package	1	1.4	1.4
		C	High Alt. Horizon Sensor	1	5.5	5.5
		D	Sun Aspect Sensor	5	2.3	11.5
		E	Remote Terminal	1	2.0	2.0
		F	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			55.9
AVCS-5A	Sensing	A	Aux Electronics Assy (AEA)	1	4.5	4.5
		B	Rate Gyro Package	1	1.4	1.4
		C	Low Alt. Horizon Sensor	1	5.5	5.5
		D	Sun Aspect Sensor	5	2.3	11.5
		E	Remote Terminal	1	2.0	2.0
		F	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			55.9
AVCS-6A	Sensing	A	Aux Electronics Assy (AEA)	1	4.5	4.5
		B	Gimballed Star Tracker	1	18.1	18.1
		C	Low Alt. Horizon Sensor	1	5.4	5.4
		D	Sun Sensor	5	2.3	11.5
		E	Remote Terminal	1	2.0	2.0
		F	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			72.5

NOTE: AR = As Required

Table A-1. Standardized Subsystem Modules
Attitude and Velocity Control System (Cont'd)

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
AVCS-7	Hot Gas Propulsion (N_2H_4) Small Tank	A	Nitrogen Tank (7.5-in OD)	1	2.3	2.3
		B	Start Valve	1	0.5	0.5
		C	Regulator Valve	1	1.8	1.8
		D	Temperature Tranducer	2	0.05	0.1
		E	Pressure Transducer	2	0.05	0.1
		F	Hydrazine Tank (15-in OD)	1	4.0	4.0
		G	Latching Valves	2	0.5	1.0
		H	Thruster (0.1 lb)	4	0.9	3.6
		I	Thruster (5.0 lb)	3	1.4	4.2
		J	Remote Terminal	1	2.0	2.0
		K	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			50.6
AVCS-8	Hot Gas Propulsion (N_2H_4) (Large Tank)	A	Nitrogen Tank (7.5-in OD)	1	2.3	2.3
		B	Start Valve	1	0.5	0.5
		C	Regulator Valve	1	1.8	1.8
		D	Temperature Tranducer	2	0.05	0.1
		E	Pressure Transducer	2	0.05	0.1
		F	Hydrazine Tank (24-in OD)	1	11.0	11.0
		G	Latching Valves	2	0.5	1.0
		H	Thruster (0.1 lb)	4	0.9	3.6
		I	Thruster (5.0 lb)	3	1.4	4.2
		J	Remote Terminal	1	2.0	2.0
		K	Power Conditioning	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			57.6

NOTE: AR = As Required

Table A-2. Standard Subsystem Modules
Guidance and Navigation

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
GN-1	Intertial Measuring Unit	A	Control and Readout Electronics	1	18.1	18.1
		B	Three Rate and Rate Integration Gyro Assy.	1	18.1	18.1
		C	Three Accelerometry Assembly	1	9.1	9.1
		D	Power Conditioning	1	2.0	2.0
		E	Remote Terminal	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			78.3
GN-2	Guidance & Control Processor Assembly	A	Input/Out Unit	1	3.2	3.2
		B	Memory Unit	1	3.2	3.2
		C	Arithmetic & Control Unit	1	3.2	3.2
		D	Power Conditioning	1	2.0	2.0
		E	Remote Terminal	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			42.6

NOTE: AR = As Required

Table A-3. Standardized Subsystem Modules
Telemetry, Tracking and Command

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
TTC-1	Telemetry, Tracking & Command	A	Transmitter(C Band,0.1W)	1	2.0	2.0
		B	Receiver (C-Band)	2	4.0	8.0
		C	Signal Condition	2	2.0	4.0
		D	Horn Antenna (C-Band)	1	2.0	2.0
		E	Diplexer	1	1.0	1.0
		F	Hybrid	1	1.0	1.0
		G	Power Conditioning	1	2.0	2.0
		H	Remote Terminal	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			51.0
TTC-5	Telemetry, Tracking & Command	A	Transmitter(S Band, 8W)	2	2.0	4.0
		B	Receiver (S-Band)	2	4.0	8.0
		C	Signal Condition	2	2.0	4.0
		D	Baseband Assembly	1	1.0	1.0
		E	Omni Antenna (S-Band)	2	1.0	2.0
		F	Diplexer	1	1.0	1.0
		G	Hybrid	1	1.0	1.0
		H	Power Conditioning	1	2.0	2.0
		I	Remote Terminal	1	2.0	2.0
		J	Recorder #1(1)	1	7.0	7.0
			Cabling	AR	5.0	5.0
			Connector	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			61.0

(1) Recorder #1 Off-the-shelf (1 Mbit/sec)

NOTE: AR = As Required

Table A-3. Standardized Subsystem Modules
Telemetry, Tracking and Command (Cont'd)

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
TTC-6	Telemetry, Tracking & Command	A	Transmitter (S-band 8W)	2	2.0	4.0
		B	Receiver (S-band)	2	4.0	8.0
		C	Signal Condition	2	2.0	4.0
		D	Baseband Assembly	1	1.0	1.0
		E	Dish Antenna(S-band, 1.5')	1	1.0	1.0
		F	Omni Antenna (S-band)	1	1.0	1.0
		G	Diplexer	1	1.0	1.0
		H	Hybrid	1	1.0	1.0
		I	Power Conditioning	1	2.0	2.0
		J	Remote Terminal	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connectors	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			54.0
TTC-8	Telemetry, Tracking & Command	A	Transmitter (S-band, 40W)	1	8.0	8.0
		B	Receiver (S-band)	2	4.0	8.0
		C	Signal Condition	2	2.0	4.0
		D	Tracking Circuitry	1	2.0	2.0
		E	Tracking Ant. (S-band, 1.5')	1	3.0	3.0
		F	Omni Antenna (S-band)	1	1.0	1.0
		G	Antenna Drive	1	2.0	2.0
		H	Hybrid	1	1.0	1.0
		I	Power Conditioning	1	2.0	2.0
		J	Remote Terminal	1	2.0	2.0
			Cabling	AR	5.0	5.0
			Connector	AR	2.0	2.0
			Environmental Protection	AR	5.0	5.0
			Structure	AR	17.0	17.0
			TOTAL:			62.0

NOTE: AR = As Required

Table A-4. Standardized Subsystem Modules
Data Processing

Module Code	Module Name	Item	Component	Qty	Weight (kg)	
					Item	Total
DP-1	Data Processing	A	Program Storage Memory	1	2.0	2.0
		B	Data Bus Processor	1	4.0	4.0
		C	Data Storage Memory	1	3.0	3.0
		D	I/O Processor	1	4.6	4.6
		E	Power Conditioning	1	3.2	3.2
		F	Cabling & Connectors	1	8.2	8.2
			Connectors	1	2.3	2.3
			Environmental Protection	1	4.5	4.5
			Structure	1	15.0	15.0
			TOTAL:			46.8

Table A-5. Standardized Subsystem Modules
Electrical Power System

Module Code	Module Name	Item	Component	Qty	Weight (kg) Item	Weight (kg) Total
EPS-1A	Battery	A	6 AH Battery	2	7.2	14.0
		B	Charge Controller	2	4.5	9.0
			Cables	AR		3.0
			Connectors	AR		2.0
			Structure	AR		17.0
			Environmental Protection	AR		5.0
			TOTAL:			50.0
EPS-1C	Battery	A	6 AH Battery	6	7.2	43.0
		B	Charge Controller	6	4.5	27.0
			Cables	AR		8.0
			Connectors	AR		5.0
			Structure	AR		17.0
			Environmental Protection	AR		5.0
			TOTAL:			105.0
EPS-2	Battery	A	50 AH Battery	2	47.6	95.0
		B	Charge Controller	2	4.5	9.0
			Cables	AR		3.0
			Connectors	AR		2.0
			Structure	AR		17.0
			Environmental Protection	AR		5.0
			TOTAL:			131.0
EPS-3	Solar Array Dr.	A	Motor	1	9.0	9.0
		B	Engage Mechanism	1	14.5	15.0
			Cables	AR		3.0
			Connectors	AR		2.0
			Structure	AR		17.0
			Environmental Protection	AR		5.0
			TOTAL:			51.0

NOTE: AR = As Required

APPENDIX B

This appendix contains a computer printout of the satellite weights generated by the synthesis methods discussed in subsections 5.3 and 5.4 of this report. The four reference satellites are listed first, followed by the five selected examples. The data resulting from the use of the subsystem similarity selection process (buildup) appears on the first nine pages, while the results of the equation method are shown in the final nine pages.

CODE NUMBER : 100. SEO   08/26/74

IX = .7838
IY = IZ = 1.410

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	SEO 10	1.00	1.00	0.00	133.	261.	757.	998.	542.
ENVIRON. CONT.	SEO 10	2.30	2.60	1.00	11.	12.	25.	29.	53.
GUID. NAV. + STAB.	SEO 2	1.07	1.07	2.05	135.	136.	146.	146.	280.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	SEO 3	1.28	1.28	2.21	70.	80.	43.	48.	155.
C. D. P. I.	SEO 2	1.28	1.28	1.09	147.	147.	188.	188.	160.
ELECTRICAL	SEO 2	1.81	1.81	1.75	312.	334.	565.	565.	546.
MISS. EQUIPMENT	SEO 2	1.47	1.47	1.00	294.	234.	432.	432.	294.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	1103.	1265.	2156.	2404.	2030.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	60.	69.	196.	219.	110.
WET WEIGHT		0.00	0.00	0.00	1163.	1333.	2352.	2623.	2141.
ADAPTER WEIGHT		0.00	0.00	0.00	72.	180.	165.	177.	112.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	1235.	1513.	2517.	2800.	2253.

	A	B	C	D	STANDARD
LENGTH (FT.)	7.0	7.3	8.5	9.1	0.0
DIAMETER (FT.)	5.0	5.2	8.5	9.1	10.0
VOLUME (CU. FT.)	137.0	156.6	489.3	585.2	0.0
DENSITY (LB/CU.FT)	8.5	8.5	4.8	4.5	0.0
SATELLITE LIFE	3.0	3.0	3.3	3.3	3.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	2.5	4.7	3.1	2.8	2.3
THICKNESS (IN.)	.0400	.0400	.0483	.0507	.0407
STR. FACT.	.129	.129	.475	.614	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					13.1
MISS. EQ. DIAM.(FT)					6.6
SAT. ENVELOPE LG.)					16.1
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					10.62

CODE NUMBER # 110. EOS 08/26/74

IX = 5.7963
IY = IZ = 20.9653

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	EOS 10	1.00	1.00	0.00	865.	1240.	1703.	2097.	1202.
ENVIRON. CONT.	EOS 10	2.04	2.21	1.00	110.	119.	224.	243.	119.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.95	195.	135.	211.	211.	380.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	EOS 3	1.28	1.28	1.64	230.	260.	78.	84.	377.
C. D. P. I.	EOS 2	.64	.64	1.01	360.	360.	230.	230.	364.
ELECTRICAL	EOS 2	2.40	2.40	1.13	830.	916.	1992.	1992.	938.
MISS. EQUIPMENT	EOS 1	1.00	1.00	1.00	1192.	1192.	1192.	1192.	1192.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	3782.	4271.	5631.	6049.	4571.
S.E.P. PROPEL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	145.	164.	360.	387.	175.
WET WEIGHT		0.00	0.00	0.00	3927.	4435.	5990.	6436.	4746.
ADAPTER WEIGHT		0.00	0.00	0.00	79.	255.	120.	129.	153.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	4005.	4689.	6110.	6565.	4899.

	A	B	C	D	STANDARD
LENGTH (FT.)	16.0	16.7	14.1	14.6	0.0
DIAMETER (FT.)	7.4	7.7	14.1	14.6	10.0
VOLUME (CU. FT.)	689.0	776.2	2192.9	2466.4	0.0
DENSITY (LB/CU.FT)	5.7	5.7	2.7	2.6	0.8
SATELLITE LIFE	3.0	3.0	3.3	3.3	3.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	1.3	3.5	.5	.5	2.3
THICKNESS (IN.)	.0626	.0681	.0729	.0755	.0552
STR. FACT.	.282	.282	.397	.483	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					23.5
MISS. EQ. DIAM. (FT)					7.1
SAT. ENVELOPE LG.)					26.5
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					19.14

CODE NUMBER : 120. OAO 08/26/74

IX = 7.4983

IY = IZ = 26.7325

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B 400 CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 16	1.00	1.00	0.00	1141.	1535.	2083.	2425.	1150.
ENVIRON. CONT.	OAO 5	2.31	2.48	1.00	100.	108.	231.	248.	116.
GUID. NAV. & STAB.	OAO 1	1.15	1.15	1.50	715.	716.	823.	823.	1074.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	OAO 5	1.28	1.28	1.63	133.	149.	36.	38.	217.
C. D. P. I.	OAO 1	.71	.71	.59	455.	456.	324.	324.	269.
ELECTRICAL	OAO 2	1.44	1.44	.56	1232.	1327.	1774.	1774.	690.
MISS. EQUIPMENT	OAO 1	1.94	1.94	1.00	967.	957.	1876.	1876.	967.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	4745.	5318.	7067.	7508.	4480.
S.E.P. PROPEL..		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	66.	74.	164.	174.	62.
WET WEIGHT		0.00	0.00	0.00	4811.	5392.	7231.	7682.	4543.
ADAPTER WEIGHT		0.00	0.00	0.00	96.	272.	145.	154.	150.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	4907.	5663.	7375.	7835.	4693.

	A	B	C	D	STANDARD
LENGTH (FT.)	17.0	17.7	17.6	19.4	0.0
DIAMETER (FT.)	7.6	7.9	14.7	14.7	10.0
VOLUME (CU. FT.)	771.0	863.8	2971.0	3275.9	0.0
DENSITY (LB/CU.FT)	5.2	6.2	2.4	2.3	0.0
SATELLITE LIFE	1.5	1.5	1.7	1.7	1.5
MEAN MISS. DURATION	1.0	1.0	1.0	1.0	1.0
ADAPT. LENGTH (FT)	1.2	3.4	.5	.5	2.3
THICKNESS (IN.)	.0685	.0741	.0813	.0847	.0543
STR. FACT.	.311	.311	.383	.461	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					9.8
MISS. EQ. DIAM.(FT)					4.0
SAT. ENVELOPE LG.)					12.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					19.74

CODE NUMBER : 130. COM

IX = 7.3566
IY = IZ = 9.6125

10/26/74

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	COM 10	1.00	1.00	0.00	450.	697.	1464.	1875.	838.
ENVIRON. CONT.	COM 10	1.54	1.74	1.00	75.	82.	115.	130.	83.
GUID. NAV. + STAB.	COM 7	1.79	1.79	1.06	125.	125.	224.	224.	132.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	1.09	200.	228.	246.	275.	218.
C. D. P. I.	COM 5	.75	.75	1.75	60.	60.	45.	45.	105.
ELECTRICAL	COM 7	1.45	1.45	1.04	724.	770.	1050.	1050.	753.
MISS. EQUIPMENT	COM 5	1.09	1.09	1.00	690.	690.	752.	752.	690.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	2324.	2652.	3896.	4351.	2819.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	405.	461.	1131.	1264.	491.
WET WEIGHT		0.00	0.00	0.00	2729.	3114.	5027.	5615.	3310.
ADAPTER WEIGHT		0.00	0.00	0.00	55.	141.	101.	112.	133.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	2784.	3255.	5127.	5728.	3442.

	A	B	C	D	STANDARD
LENGTH (FT.)	11.0	11.5	12.8	13.6	0.0
DIAMETER (FT.)	10.0	10.4	12.8	13.6	10.0
VOLUME (CU. FT.)	864.0	983.3	1652.6	1978.3	0.0
DENSITY (LB/CU.FT)	3.2	3.2	3.0	2.8	0.0
SATELLITE LIFE	7.5	7.5	8.3	8.3	7.5
MEAN MISS. DURATION	5.0	5.0	5.0	5.0	5.0
ADAPT. LENGTH (FT)	.5	2.1	.9	.5	2.3
THICKNESS (IN.)	.0566	.0555	.0673	.0707	.0481
STR. FACT.	.197	.197	.411	.501	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					2.0
MISS. EQ. DIAM.(FT)					4.5
SAT. ENVELOPE LG.)					5.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					14.50

CODE NUMBER : 3. AST-3 08/26/74

IX = 1.3319

IY = IZ = 4.2177

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	1000.	1311.	1370.	1535.	860.
ENVIRON. CONT.	OAO 5	5.12	5.37	1.00	0.	0.	0.	0.	05.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.95	500.	500.	540.	540.	975.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	EOS 3	1.28	1.28	1.64	51.	56.	49.	51.	82.
C. D. P. I.	SRS 1	1.08	1.08	1.00	143.	143.	154.	154.	143.
ELECTRICAL	OAO 2	1.44	1.44	.56	350.	410.	504.	504.	196.
MISS. EQUIPMENT	SEO 2	1.47	1.47	1.00	945.	945.	1389.	1389.	945.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	2988.	3365.	4006.	4173.	3286.
S.E.P. PROPEL..		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	100.	112.	223.	233.	110.
WET WEIGHT		0.00	0.00	0.00	3088.	3477.	4229.	4406.	3396.
ADAPTER WEIGHT		0.00	0.00	0.00	104.	264.	118.	121.	134.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	3192.	3741.	4347.	4527.	3530.

	A	B	C	D	STANDARD
LENGTH (FT.)	8.0	10.3	11.7	12.0	0.0
DIAMETER (FT.)	4.0	5.2	11.7	12.0	10.0
VOLUME (CU. FT.)	192.0	215.6	1254.3	1344.0	0.0
DENSITY (LB/CU.FT)	16.1	16.1	3.4	3.3	0.0
SATELLITE LIFE	2.0	2.0	3.3	3.3	2.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	3.0	4.6	1.5	1.4	2.3
THICKNESS (IN.)	.0517	.0583	.0624	.0635	.0486
STR. FACT.	.479	.479	.479	.535	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					4.0
MISS. EQ. DIAM. (FT)					6.0
SAT. ENVELOPE LG.)					7.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					12.94

CODE NUMBER : 2. PHY-2A 08/26/74

IX = 1.5882

IY = IZ = 3.4337

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	70.	159.	1313.	1872.	317.
ENVIRON. CONT.	OAO 5	2.88	3.41	1.00	50.	62.	144.	176.	31.
GUID. NAV. + STAB.	EOS 3	.47	.47	1.95	50.	50.	23.	23.	98.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	1.09	40.	47.	395.	499.	44.
C. D. P. I.	BL	1.00	1.00	1.00	0.	0.	0.	0.	0.
ELECTRICAL	OAO 2	1.44	1.44	.56	260.	274.	374.	374.	146.
MISS. EQUIPMENT	SEO 2	1.47	1.47	1.00	250.	250.	367.	367.	250.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	720.	852.	2617.	3307.	885.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	300.	355.	1815.	2295.	367.
WET WEIGHT		0.00	0.00	0.00	1020.	1207.	4432.	5603.	1252.
ADAPTER WEIGHT		0.00	0.00	0.00	40.	138.	89.	112.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	1060.	1345.	4521.	5715.	1362.

	A	B	C	D	STANDARD
LENGTH (FT.)	12.0	13.3	16.2	20.6	0.0
DIAMETER (FT.)	7.6	8.4	14.7	14.7	10.0
VOLUME (CU. FT.)	633.0	746.3	2744.6	3473.7	0.0
DENSITY (LB/CU.FT)	1.6	1.6	1.6	1.6	0.0
SATELLITE LIFE	1.0	1.0	1.7	1.7	1.0
MEAN MISS. DURATION	1.0	1.0	1.0	1.0	1.0
ADAPT. LENGTH (FT)	1.2	3.1	.5	.5	2.3
THICKNESS (IN.)	.0400	.0430	.0665	.0758	.0400
STR. FACT.	.374	.374	.421	.502	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					3.0
MISS. EQ. DIAM.(FT)					4.0
SAT. ENVELOPE LG.)					6.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					5.57

CODE NUMBER ! 6. NEO-6

IX = 2.3808
IY = IZ = 4.7617

08/26/74

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	300.	450.	639.	859.	363.
ENVIRON. CONT.	OAO 5	1.23	1.34	1.00	0.	0.	0.	0.	36.
GUID. NAV. & STAB.	EOS 3	1.08	1.08	1.95	63.	50.	65.	65.	117.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	1.09	53.	57.	44.	50.	54.
C. D. P. I.	BL	1.00	1.00	1.00	50.	50.	50.	50.	50.
ELECTRICAL	OAO 2	1.44	1.44	.56	250.	276.	360.	360.	140.
MISS. EQUIPMENT	EOS 1	1.00	1.00	1.00	580.	580.	580.	580.	580.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	1290.	1473.	1738.	1963.	1341.
S.E.P. PROPELL.		0.00	0.00	0.00	3.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	90.	102.	202.	229.	94.
WET WEIGHT		0.00	0.00	0.00	1380.	1575.	1940.	2192.	1635.
ADAPTER WEIGHT		0.00	0.00	0.00	35.	152.	120.	129.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	1415.	1727.	2060.	2321.	1545.

	A	B	C	D	STANDARD
LENGTH (FT.)	12.0	12.5	10.3	10.7	0.0
DIAMETER (FT.)	8.0	8.4	10.3	10.7	10.0
VOLUME (CU. FT.)	603.0	685.6	846.7	958.8	0.0
DENSITY (LB/CU.FT)	2.3	2.3	2.3	2.3	0.0
SATELLITE LIFE	2.0	2.0	3.3	3.3	2.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	1.0	3.2	2.2	2.0	2.3
THICKNESS (IN.)	.0400	.0436	.0456	.0480	.0400
STR. FACT.	.278	.278	.491	.644	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					2.7
MISS. EQ. DIAM.(FT)					4.4
SAT. ENVELOPE LG.)					5.7
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					4.00

CODE NUMBER : 9. EOP-9 08/26/74

IX = .1659

IY = IZ = .1704

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	SEO 10	1.00	1.00	0.00	47.	137.	232.	325.	139.
ENVIRON. CONT.	SEO 10	1.66	1.85	1.00	5.	6.	8.	9.	14.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.95	50.	50.	54.	54.	98.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	EOS 3	1.28	1.28	1.64	20.	25.	30.	35.	33.
C. D. P. I.	SEO 2	1.28	1.28	1.09	36.	36.	46.	46.	39.
ELECTRICAL	SEO 2	1.81	1.81	1.75	65.	70.	118.	118.	114.
MISS. EQUIPMENT	EOS 1	1.00	1.00	1.00	40.	40.	40.	40.	40.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	263.	334.	528.	627.	476.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	41.	52.	137.	162.	74.
WET WEIGHT		0.00	0.00	0.00	304.	385.	665.	789.	550.
ADAPTER WEIGHT		0.00	0.00	0.00	75.	184.	177.	179.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	380.	559.	842.	968.	661.

	A	B	C	D	STANDARD
LENGTH (FT.)	4.0	4.3	5.6	5.9	0.0
DIAMETER (FT.)	4.5	4.8	5.6	5.9	10.0
VOLUME (CU. FT.)	62.5	78.3	136.1	160.5	0.0
DENSITY (LB/CU.FT)	4.9	4.9	4.9	4.9	0.0
SATELLITE LIFE	10.0	10.0	1.7	1.7	10.0
MEAN MISS. DURATION	1.0	1.0	1.0	1.0	1.0
ADAPT. LENGTH (FT)	2.8	4.9	4.5	4.4	2.3
THICKNESS (IN.)	.0400	.0400	.0400	.0400	.0400
STR. FACT.	.183	.183	.537	.700	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					1.0
MISS. EQ. DIAM.(FT)					2.8
SAT. ENVELOPE LG.)					4.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					3.02

CODE NUMBER 1   5. NNO-5   08/26/74

IX = .6075
IY = IZ = 1.036

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	SEQ 10	1.00	1.00	0.00	137.	227.	538.	806.	284.
ENVIRON. CONT.	SEQ 10	1.77	2.06	1.00	17.	19.	30.	35.	28.
GUID. NAV. + STAB.	SEQ 2	1.07	1.07	2.06	74.	74.	79.	79.	152.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	1.69	40.	48.	98.	124.	44.
C. D. P. I.	BL	1.00	1.00	1.00	25.	26.	26.	26.	26.
ELECTRICAL	SEQ 2	1.81	1.81	1.75	168.	179.	304.	304.	294.
MISS. EQUIPMENT	COM 5	1.09	1.09	1.00	81.	81.	88.	88.	81.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	543.	654.	1164.	1463.	909.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	127.	152.	453.	569.	212.
WET WEIGHT		0.00	0.00	0.00	670.	806.	1617.	2032.	1121.
ADAPTER WEIGHT		0.00	0.00	0.00	64.	170.	143.	161.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	734.	976.	1760.	2193.	1232.

	A	B	C	D	STANDARD
LENGTH (FT.)	7.8	8.3	8.5	9.2	0.0
DIAMETER (FT.)	5.8	6.1	8.5	9.2	10.0
VOLUME (CU. FT.)	205.0	245.5	492.4	619.5	0.0
DENSITY (LB/CU.FT)	3.3	3.3	3.3	3.3	0.0
SATELLITE LIFE	7.0	7.0	11.7	11.7	7.0
MEAN MISS. DURATION	7.0	7.0	7.0	7.0	7.0
ADAPT. LENGTH (FT)	2.1	4.3	3.1	2.7	2.3
THICKNESS (IN.)	.0400	.0400	.0419	.0450	.0400
STR. FACT.	.257	.257	.499	.658	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					4.0
MISS. EQ. DIAM.(FT)					5.3
SAT. ENVELOPE LG.)					7.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					6.15

CODE NUMBER 1 0. SEO 08/26/74

IX = .7839
IY = IZ = 1.4100

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	SEO 10	1.00	1.00	0.00	133.	261.	757.	998.	521.
ENVIRON. CONT.	SEO 10	2.30	2.60	1.00	11.	12.	25.	29.	51.
GUID. NAV. + STAB.	SEO 2	1.07	1.07	1.67	135.	136.	146.	146.	227.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	SEO 3	1.28	1.28	2.07	73.	80.	43.	48.	145.
C. D. P. I.	SEO 2	1.28	1.28	1.37	147.	147.	188.	188.	201.
ELECTRICAL	SEO 2	1.81	1.81	1.64	312.	334.	565.	565.	512.
MISS. EQUIPMENT	SEO 2	1.47	1.47	1.00	294.	294.	432.	432.	294.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	3.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	1103.	1265.	2156.	2404.	1950.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	60.	69.	196.	219.	106.
WET WEIGHT		0.00	0.00	0.00	1163.	1333.	2352.	2623.	2056.
ADAPTER WEIGHT		0.00	0.00	0.00	72.	180.	165.	177.	111.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	1235.	1513.	2517.	2800.	2167.

	A	B	C	D	STANDARD
LENGTH (FT.)	7.0	7.3	8.5	9.1	8.0
DIAMETER (FT.)	5.0	5.2	8.5	9.1	10.0
VOLUME (CU. FT.)	137.0	156.5	489.3	585.2	0.0
DENSITY (LB/CU.FT)	8.5	8.5	4.8	4.5	0.0
SATELLITE LIFE	3.0	3.0	3.3	3.3	3.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	2.5	4.7	3.1	2.8	2.3
THICKNESS (IN.)	.0400	.0400	.0483	.0507	.0400
STR. FACT.	.129	.129	.475	.614	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					13.1
MISS. EQ. DIAM.(FT)					6.6
SAT. ENVELOPE LG.)					16.1
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					10.10

CODE NUMBER : 10. EOS

IX = 5.7969

IY = IZ = 20.9653

10/26/74

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	EOS 10	1.00	1.00	0.00	865.	1240.	1703.	2097.	1110.
ENVIRON. CONT.	EOS 10	2.04	2.21	1.00	110.	119.	224.	243.	109.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.65	195.	195.	211.	211.	322.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	EOS 3	1.28	1.28	1.30	233.	260.	78.	84.	300.
C. D. P. I.	EOS 2	.64	.64	.89	360.	360.	230.	230.	320.
ELECTRICAL	EOS 2	2.40	2.40	1.05	833.	906.	1992.	1992.	868.
MISS. EQUIPMENT	EOS 1	1.00	1.00	1.00	1192.	1192.	1192.	1192.	1192.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	3782.	4271.	5631.	6049.	4221.
S.E.P. PROPEL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	145.	164.	360.	387.	162.
WET WEIGHT		0.00	0.00	0.00	3927.	4435.	5990.	6436.	4303.
ADAPTER WEIGHT		0.00	0.00	0.00	79.	255.	120.	129.	148.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	4005.	4609.	6110.	6565.	4531.

	A	B	C	D	STANDARD
LENGTH (FT.)	15.0	16.7	14.1	14.6	0.0
DIAMETER (FT.)	7.4	7.7	14.1	14.6	10.0
VOLUME (CU. FT.)	689.0	776.2	2192.9	2466.4	0.0
DENSITY (LB/CU.FT)	5.7	5.7	2.7	2.6	0.0
SATELLITE LIFE	3.0	3.0	3.3	3.3	3.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	1.3	3.5	.5	.5	2.3
THICKNESS (IN.)	.0626	.0681	.0729	.0755	.0536
STR. FACT.	.282	.282	.397	.483	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					23.5
MISS. EQ. DIAM. (FT)					7.1
SAT. ENVELOPE LG.)					25.5
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					16.93

CODE NUMBER : 20. OAO

IX = 7.4909
IY = IZ = 28.7325

08/26/74

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	1141.	1595.	2003.	2425.	1186.
ENVIRON. CONT.	OAO 5	2.31	2.48	1.00	100.	108.	231.	248.	117.
GUID. NAV. + STAB.	OAO 1	1.15	1.15	1.52	715.	716.	823.	823.	1089.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	OAO 5	1.28	1.28	1.77	133.	149.	36.	38.	235.
C. D. P. I.	OAO 1	.71	.71	.67	455.	456.	324.	324.	307.
ELECTRICAL	OAO 2	1.44	1.44	.58	1232.	1327.	1774.	1774.	719.
MISS. EQUIPMENT	OAO 1	1.94	1.94	1.00	967.	957.	1876.	1876.	967.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	4745.	5318.	7067.	7508.	4626.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	65.	74.	164.	174.	64.
NET WEIGHT		0.00	0.00	0.00	4811.	5392.	7231.	7682.	4684.
ADAPTER WEIGHT		0.00	0.00	0.00	96.	272.	145.	154.	152.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	4967.	5653.	7375.	7835.	4836.

	A	B	C	D	STANDARD
LENGTH (FT.)	[illegible]	17.7	17.6	19.4	0.0
DIAMETER (FT.)	7.6	7.9	14.7	14.7	10.0
VOLUME (CU. FT.)	771.0	863.9	2971.0	3275.9	0.0
DENSITY (LB/CU.FT)	5.2	6.2	2.4	2.3	0.0
SATELLITE LIFE	1.5	1.5	1.7	1.7	1.5
MEAN MISS. DURATION	1.0	1.0	1.0	1.0	1.0
ADAPT. LENGTH (FT)	1.2	3.4	.5	.5	2.3
THICKNESS (IN.)	.0685	.0741	.0813	.0847	.0549
STR. FACT.	.311	.311	.383	.461	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					9.8
MISS. EQ. DIAM.(FT)					4.0
SAT. ENVELOPE LG.)					15.8
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					20.60

CODE NUMBER : 30. COM

08/26/74

IX = 7.3565
IY = IZ = 9.6125

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	COM 10	1.00	1.00	0.00	450.	697.	1464.	1875.	939.
ENVIRON. CONT.	COM 10	1.54	1.74	1.00	75.	82.	115.	130.	93.
GUID. NAV. + STAB.	COM 7	1.79	1.79	1.67	125.	125.	224.	224.	209.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	1.45	200.	228.	246.	275.	289.
C. D. P. I.	COM 5	.75	.75	1.55	60.	60.	45.	45.	94.
ELECTRICAL	COM 7	1.45	1.45	1.17	724.	770.	1050.	1050.	845.
MISS. EQUIPMENT	COM 5	1.09	1.09	1.00	691.	690.	752.	752.	690.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	2324.	2652.	3896.	4351.	3159.
S.E.P. PROPEL..		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	405.	461.	1131.	1264.	550.
WET WEIGHT		0.00	0.00	0.00	2729.	3114.	5027.	5615.	3709.
ADAPTER WEIGHT		0.00	0.00	0.00	55.	141.	101.	112.	139.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	2784.	3255.	5127.	5728.	3848.

	A	B	C	D	STANDARD
LENGTH (FT.)	11.0	11.5	12.8	13.6	0.0
DIAMETER (FT.)	10.0	10.4	12.8	13.6	10.0
VOLUME (CU. FT.)	864.0	983.3	1652.6	1978.0	0.0
DENSITY (LB/CU.FT)	3.2	3.2	3.0	2.8	0.0
SATELLITE LIFE	7.5	7.5	8.3	8.3	7.5
MEAN MISS. DURATION	5.0	5.0	5.0	5.0	5.0
ADAPT. LENGTH (FT)	.5	2.1	.9	.5	2.3
THICKNESS (IN.)	.0506	.0555	.0673	.0737	.0502
STR. FACT.	.197	.197	.411	.501	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					2.0
MISS. EQ. DIAM.(FT)					4.5
SAT. ENVELOPE LG.)					5.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					16.92

CODE NUMBER : 3. AST-3 08/26/74

IX = 1.3319
IY = IZ = 4.2177

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	1003.	1311.	1370.	1535.	954.
ENVIRON. CONT.	OAO 5	5.12	5.37	1.00	0.	0.	0.	0.	94.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.58	503.	500.	540.	540.	788.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	EOS 3	1.28	1.28	2.16	53.	56.	49.	51.	108.
C. D. P. I.	SRS 1	1.08	1.08	1.38	143.	143.	154.	154.	197.
ELECTRICAL	OAO 2	1.44	1.44	1.60	350.	410.	504.	504.	559.
MISS. EQUIPMENT	SEO 2	1.47	1.47	1.00	945.	945.	1389.	1389.	945.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	2988.	3365.	4006.	4173.	3644.
S.E.P. PROPEL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	103.	112.	223.	233.	122.
WET WEIGHT		0.00	0.00	0.00	3083.	3477.	4229.	4406.	3766.
ADAPTER WEIGHT		0.00	0.00	0.00	104.	264.	118.	121.	140.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	3192.	3741.	4347.	4527.	3906.

	A	B	C	D	STANDARD
LENGTH (FT.)	8.0	10.3	11.7	12.0	0.0
DIAMETER (FT.)	4.0	5.2	11.7	12.0	10.0
VOLUME (CU. FT.)	192.0	219.5	1254.3	1344.0	0.0
DENSITY (LB/CU.FT)	16.1	16.1	3.4	3.3	0.0
SATELLITE LIFE	2.0	2.0	3.3	3.3	2.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.0	2.0
ADAPT. LENGTH (FT)	3.0	4.0	1.5	1.4	2.3
THICKNESS (IN.)	.0517	.0583	.0624	.0635	.0505
STR. FACT.	.479	.479	.479	.535	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					4.0
MISS. EQ. DIAM.(FT)					6.0
SAT. ENVELOPE LG.)					7.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					15.20

CODE NUMBER : 2. PHY-2A   08/26/74

IX = 1.5882
IY = IZ = 3.4337

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	70.	159.	1313.	1872.	512.
ENVIRON. CONT.	OAO 5	2.88	3.41	1.60	50.	62.	144.	170.	50.
GUID. NAV. + STIB.	EOS 3	.47	.47	1.69	50.	50.	23.	23.	84.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	2.21	40.	47.	395.	499.	88.
C. D. P. I.	BL	1.00	1.00	1.70	0.	0.	0.	0.	0.
ELECTRICAL	OAO 2	1.44	1.44	1.70	260.	274.	374.	374.	442.
MISS. EQUIPMENT	SEO 2	1.47	1.47	1.00	250.	250.	367.	367.	250.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	720.	852.	2617.	3307.	1427.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	300.	355.	1815.	2295.	594.
WET WEIGHT		0.00	0.00	0.00	1020.	1207.	4432.	5603.	2021.
ADAPTER WEIGHT		0.00	0.00	0.00	40.	138.	89.	112.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	1060.	1345.	4521.	5715.	2132.

	A	B	C	D	STANDARD
LENGTH (FT.)	12.0	13.3	16.2	20.6	0.0
DIAMETER (FT.)	7.6	8.4	14.7	14.7	10.0
VOLUME (CU. FT.)	633.0	745.3	2744.6	3473.7	0.0
DENSITY (LB/CU.FT)	1.6	1.6	1.6	1.6	0.0
SATELLITE LIFE	1.0	1.0	1.7	1.7	1.0
MEAN MISS. DURATION	1.0	1.0	1.0	1.0	1.0
ADAPT. LENGTH (FT)	1.2	3.1	.5	.5	2.3
THICKNESS (IN.)	.0400	.0400	.0665	.0758	.0400
STR. FACT.	.074	.074	.421	.502	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					3.0
MISS. EQ. DIAM.(FT)					4.0
SAT. ENVELOPE LG.)					6.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					10.25

CODE NUMBER : 6. NEO-6 08/26/74

IX = 2.3808
IY = IZ = 4.7617

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B 400 CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	OAO 10	1.00	1.00	0.00	300.	450.	539.	859.	500.
ENVIRON. CONT.	OAO 5	1.23	1.34	1.00	0.	0.	0.	0.	49.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.69	60.	50.	65.	65.	101.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	2.16	50.	57.	44.	50.	108.
C. D. P. I.	BL	1.00	1.00	1.59	50.	50.	50.	50.	79.
ELECTRICAL	OAO 2	1.44	1.44	1.71	250.	276.	360.	360.	428.
MISS. EQUIPMENT	EOS 1	1.00	1.00	1.00	580.	580.	580.	580.	580.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	1290.	1473.	1738.	1963.	1846.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	90.	102.	202.	229.	129.
WET WEIGHT		0.00	0.00	0.00	1380.	1575.	1940.	2192.	1974.
ADAPTER WEIGHT		0.00	0.00	0.00	35.	152.	120.	129.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	1415.	1727.	2060.	2321.	2085.

	A	B	C	D	STANDARD
LENGTH (FT.)	12.0	12.5	10.3	10.7	0.0
DIAMETER (FT.)	8.0	8.4	10.3	10.7	10.0
VOLUME (CU. FT.)	603.0	685.6	846.7	958.8	0.0
DENSITY (LB/CU.FT)	2.3	2.3	2.3	2.3	0.0
SATELLITE LIFE	2.0	2.0	3.3	3.3	2.0
MEAN MISS. DURATION	2.0	2.0	2.0	2.3	2.0
ADAPT. LENGTH (FT)	1.0	3.2	2.2	2.0	2.3
THICKNESS (IN.)	.0400	.0436	.0456	.0480	.0400
STR. FACT.	.278	.278	.491	.644	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					2.7
MISS. EQ. DIAM. (FT)					4.4
SAT. ENVELOPE LG.)					5.7
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					7.28

CODE NUMBER : 9. EOP-9 10/26/74

IX = .1659

IY = IZ = .1704

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	SEO 10	1.00	1.00	0.00	47.	107.	232.	325.	152.
ENVIRON. CONT.	SEO 10	1.66	1.85	1.00	5.	6.	8.	9.	15.
GUID. NAV. + STAB.	EOS 3	1.08	1.08	1.69	51.	50.	54.	54.	84.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	EOS 3	1.28	1.28	2.30	20.	25.	30.	35.	46.
D. D. P. I.	SEO 2	1.28	1.28	1.62	35.	36.	46.	46.	58.
ELECTRICAL	SEO 2	1.81	1.81	1.93	65.	70.	118.	118.	125.
MISS. EQUIPMENT	EOS 1	1.00	1.00	1.00	40.	40.	40.	40.	40.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	EL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	263.	334.	528.	627.	521.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	41.	52.	137.	162.	81.
WET WEIGHT		0.00	0.00	0.00	304.	385.	665.	789.	602.
ADAPTER WEIGHT		0.00	0.00	0.00	76.	184.	177.	179.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	380.	569.	842.	968.	713.

	A	B	C	D	STANDARD
LENGTH (FT.)	4.0	4.3	5.6	5.9	0.0
DIAMETER (FT.)	4.5	4.8	5.5	5.9	10.0
VOLUME (CU. FT.)	62.5	78.3	136.1	160.5	0.0
DENSITY (LB/CU.FT)	4.9	4.9	4.9	4.9	0.0
SATELLITE LIFE	10.0	10.0	1.7	1.7	10.0
MEAN MISS. DURATION	1.0	1.0	1.0	1.0	1.0
ADAPT. LENGTH (FT)	2.8	4.9	4.5	4.4	2.3
THICKNESS (IN.)	.0400	.0400	.0400	.0400	.0400
STR. FACT.	.183	.183	.537	.700	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					1.0
MISS. EQ. DIAM.(FT)					2.8
SAT. ENVELOPE LG.)					4.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					3.33

CODE NUMBER : 5. NNO-5 10/26/74

IX = .6075
IY = IZ = 1.0364

ITEM	BASE	EXPEND FACTOR	REUSE FACTOR	STAND. FACTOR	A CURRENT WEIGHT	B MOD CURRENT	LOW COST C EXPEND WEIGHT	LOW COST D REUSE WEIGHT	STANDARD SUBSYST.
STRUCTURE	SEO 10	1.00	1.00	0.00	137.	227.	538.	806.	304.
ENVIRON. CONT.	SEO 10	1.77	2.06	1.00	17.	19.	30.	35.	30.
GUID. NAV. + STAB.	SEO 2	1.07	1.07	1.68	74.	74.	79.	79.	124.
S. E. P. DRY WT.		0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY PROPULSION		1.00	1.00	0.00	0.	0.	0.	0.	0.
DRY ATTID. CONT.	COM 7	1.28	1.28	2.21	40.	48.	98.	124.	88.
C. D. P. I.	BL	1.00	1.00	1.64	26.	26.	26.	26.	43.
ELECTRICAL	SEO 2	1.81	1.81	1.81	169.	179.	304.	304.	304.
MISS. EQUIPMENT	COM 5	1.09	1.09	1.00	81.	81.	88.	88.	81.
LANDER		0.00	0.00	0.00	0.	0.	0.	0.	0.
RESIDUALS		0.00	0.00	0.00	0.	0.	0.	0.	0.
CREW EQUIP.	BL	0.00	0.00	0.00	0.	0.	0.	0.	0.
DRY WEIGHT		0.00	0.00	0.00	543.	654.	1164.	1463.	974.
S.E.P. PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
MAIN PROPELL.		0.00	0.00	0.00	0.	0.	0.	0.	0.
ATT. CONT. PROP.		0.00	0.00	0.00	127.	152.	453.	569.	228.
WET WEIGHT		0.00	0.00	0.00	670.	806.	1617.	2032.	1202.
ADAPTER WEIGHT		0.00	0.00	0.00	64.	170.	145.	161.	110.
PALLET WEIGHT		0.00	0.00	0.00	0.	0.	0.	0.	0.
LAUNCH WEIGHT		0.00	0.00	0.00	734.	976.	1760.	2193.	1312.

	A	B	C	D	STANDARD
LENGTH (FT.)	7.8	8.3	8.6	9.2	0.0
DIAMETER (FT.)	5.8	6.1	8.6	9.2	10.0
VOLUME (CU. FT.)	205.0	249.5	492.4	519.5	0.0
DENSITY (LB/CU.FT)	3.3	3.3	3.3	3.3	0.0
SATELLITE LIFE	7.0	7.0	11.7	11.7	7.0
MEAN MISS. DURATION	7.0	7.0	7.0	7.0	7.0
ADAPT. LENGTH (FT)	2.1	4.3	3.1	2.7	2.3
THICKNESS (IN.)	.0400	.0400	.0419	.0460	.0400
STR. FACT.	.257	.257	.499	.658	.339
BOOST. DIAM. (FT)	10.0	14.7	14.7	14.7	14.7
MISS. EQ. LG. (FT)					4.0
MISS. EQ. DIAM.(FT)					5.3
SAT. ENVELOPE LG.)					7.0
SAT. ENVELOPE DIAM.)					14.5
NUMBER OF MODULES)					6.64